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Report

National Brucellosis Technical Commission

August, 1978

Prepared for

Animal and Plant Health Inspection Service

U. S. Department of Agriculture

and

United States Animal Health Association

Report

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The members of the Technical Commission are deeply indebted to many people from all over the United States who responded willingly and cheerfully to our requests for data, information, and opinions. Others permitted us to test some of our own concepts and ideas. Recognizing that these were probes rather than trial balloons they helped us with their critques, without seeking to influence our conclusions.

We each owe a debt of gratitude to members of our staffs who labored long and hard in preparation of drafts, assembly and analysis of data, searching out references and the effort involved in the preparation of this final report. We cannot adequately acknowledge their contributions.

The Chairman, however, wishes particularly to express his appreciation to the other members of the Commission for their diligent efforts, hard work and cooperation. It has been personally rewarding for me to meet and work with them, and I hope that the friendship we established during the past two years will continue.

Finally, but most importantly I must acknowledge the loyal and cheerful efforts of Joyce Wells-Powell and Sue Macho. Without them, I would never have been able to meet the schedule of meetings, preparation and distribution of documents and drafts that were required during the past two years. Their willingness to work nights and weekends during the final stages of completion of this report is the only reason we were able to meet our deadline.

In this section of our report we present eleven sets of findings and recommendations. These refer specifically to parts of the Charge to the Commission, and seem to us to address major policy questions to which we wish to give special emphasis. They are only a portion of all of the findings and recommendations, which are to be found throughout the body of the report and the appendices.

1. Finding: Effective control leading to local eradication of bovine brucellosis is biologically feasible.

Finding: If there were not a cooperative state - federal program, uncoordinated state and individual programs would be initiated, which would prove to be more costly, interfere with commerce more than the existing program, and result in significant increases in the prevalence of bovine and of human brucellosis. The Commission also finds that achievement of the goal requires the assumption by individuals of responsibility for their actions which affect control leading to eradication.

Therefore: The Commission recommends that the state and federal governments, and the industries affected support a cooperative program of control leading toward local eradication, as defined and substantiated in this report.

2. Finding: Biologic knowledge essential to accomplish control leading to local eradication is available, and has been used in many areas to reach this goal.

Finding: The levels of understanding and current knowledge of brucellosis are so low in many places, among those who have a need to know, as to constitute a major barrier to the achievement of control leading to local eradication.

Therefore: The Commission recommends increased support for ongoing cooperative state - federal - industry programs of education and training to correct these deficienies.

Specific programmatic recommendations are made in the report which address: education for producers and the marketing segments of industry so that they will have an information base from which to assume greater individual responsibility in their own interest; education targeted in terms of the individuals' need to know, at the time they have a need to know, to promote actions from a base of enlightened self-interest;

education to improve the quality of information posessed by those professionals in both the public and private sectors who have the responsibility of advising and of regulating those engaged in the production, handling and marketing of cattle and cattle products; education to increase general public awareness of all of the implications of the disease and the programs designed to achieve local eradication.

3. Finding: Using a systems simulation model, various program options, including "no governmental program" were simulated to determine their economic impact. All of the program alternatives, except the "no governmental program" option, had favorable benefit/cost ratios and produced net benefits for funds invested.

Finding: While the modeling process contains inherent limitations, which make it inappropriate to use the results obtained by such an analysis as the sole criterion for policy recommendations, the results obtained so strongly support the other approaches to analysis of the problem as to permit generalization.

Therefore: The Commission recommends recognition of the principle that investment of funds in epidemiologically sound modifications of the present program specifically targeted to varying requirements of herds, states and regions will produce a favorable return.

4. Finding: Indemnity payments accounted for 35 percent of total program obligations in FY 1976. Given the substantial costs accruing to producers from requirements of brucellosis control programs, and the benefits which accrue to the public generally, indemnity payments are appropriate to use as incentives. However, administrative problems in disbursing indemnity payments engender antiprogram feeling in some states which is strong enough to constitute a negative incentive to cooperation with the program.

Procedures necessary to obtain increases in levels of indemnity to conform with market conditions, or to implement herd depopulations are excessively complex. In some states where program components are of relatively low quality, large disbursements of federal indemnity funds are being made.

Therefore: We recommend that the progress toward improvement in the claims system represented by the BICS be accelerated. We also recommend that a study be undertaken to determine the effects of adopting an indemnity system keyed to replacement value, which moves with the market.

We recommend reexamination of the policy of making federal indemnity payments in states where program components are of relatively low quality.

5. Finding: We agree with the National Academy of Sciences Subcommittee on Brucellosis Research that the major reduction in funds for brucellosis research from 1967-75 was premature. Increased financial support for brucellosis research since 1975 is already showing promise of significant advances in the data base for improvement in vaccination practices and aid to diagnosis. Additional data basic to an understanding of brucellosis are also being developed.

Therefore: We recommend that research funding be continued at levels and for sufficient time to assure an adequate flow of new information both for presently perceived needs and for unanticipated problems which will arise. The Commission also recommends the continuation of the policy adopted by APHIS and SEA of establishing ad hoc panels of experts for peer evaluation of research and development proposals and the establishment of an advisory system to help in establishing funding priorities.

6. Finding: The dynamics of both the dairy and beef cattle industries have such an important influence on the conduct of all programs of disease control, including brucellosis, that it is essential that there be an adequate base of economic and epidemiologic data for the design of program policies, their implementation and evaluation.

Finding: While the biologic aspects of brucellosis research are fairly well covered in presently sponsored research projects, there is a need for additional research on the interaction of economics, epidemiologic factors and the dynamics of the livestock industry as they influence the prevalence of brucellosis.

Therefore: The Commission recommends that APHIS and SEA, in coordination with other appropriate federal agencies, the State Departments of Agriculture and the Land Grant Universities, sponsor ongoing research on the cyclic, geographic, movement, marketing and other economic and epidemiologic factors as they influence disease control. The Commission further recommends to APHIS and USAHA that this research generated data be used in the systematic review of brucellosis program policy, its implementation and evaluation.

7. Finding: Program data as presently collected in the states, and compiled by APHIS staff do not provide an epidemiologic or administrative data base which is adequate for precise evaluation of program and performance. Such a data base is essential for rational recommendations in support of, or for changes in program components. We recognize that APHIS is currently conducting studies on data based management systems, including several pilot operations.

Therefore: The Commission recommends that priority be given to completion of these studies, and their evaluation jointly with the states, to insure earliest possible implementation of adequate data collection and data management systems, with compatability of state and federal processing systems.

8. Finding: All of the alternatives which the Commission has examined to accomodate the expressed desires of the livestock industry for increased flexibility of programs, and which do not compromise principles of sound disease control, require the development and implementation of a nonduplicative individual animal identification system.

Therefore: The Commission recommends that by December 31, 1981, all cattle changing ownership shall have a permanent nonduplicative individual identification that can be traced to the previous owners and herd of origin. We also recommend that the States initiate action to provide the appropriate legislative and administrative authority to implement this recommendation prior to December 31, 1981.

9. Findings: Brucellosis is a serious and debilitating disease of human beings. Its incidence in the U.S. is understated in all official reports, but is clearly related to the prevalence of brucellosis in cattle, swine, goats and sheep. Increases in prevalence of bovine brucellosis in recent years have been directly associated with increases in incidence of human brucellosis caused by *Brucella abortus* among livestock producers, their families and others in the marketing and processing chain. The recent experience repeats that of the past, when prevalence of bovine brucellosis was higher nationally. There is not now a structured system to protect from, or to compensate for illness and disability occurring in members of farm families, employees or private veterinarians who are at risk of infection.

Packing house employees are presently the occupational group with the highest reported incidence of brucellosis and there is no successful program to protect them from exposure to brucellosis from infected animals presented for slaughter.

Two states have instituted regulations restricting import of branded reactor cattle for slaughter, and packing house infections are under investigation in other states by state and local health departments and the Center for Disease Control.

Therefore, the Commission recommends: That local eradication be recognized as a public benefit in that it provides protection to public health.

We recommend: That serious consideration be given to the prospect that Occupational Safety and Health standards may be imposed in the packing industry at some time unless a plan is in effect to reduce the hazards to employees through local eradication of animal brucellosis. Serious consideration must also be given to the prospect that consumer protection standards on processing brucellosis reactor cattle, comparable to those presently in force requiring cooking of branded tuberculin reactor cattle, or cattle or swine with lesions of tuberculosis.

10. Finding: Over the years, in attempts to accommodate to competing desires of various geographic and industry segments, changes in the U.M.&R. have produced trade offs of sound epidemiologic principles. In the process, the U.M.&R. has evolved into a document which contains many barriers to the achievement of control leading to local eradication. Specifically the present U.M.&R. promotes the transfer of responsibility and accountability from individuals engaged in the livestock and marketing industries to the federal and state regulatory agencies. In the process, it generates a false sense of security on the part of individuals who accept animals on the basis of rules which are epidemiologically invalid. It creates rewards for systems of evasion, thus promoting the maintenance and dissemination of bovine brucellosis.

Application of the present U.M.&R. results in continued very high costs, for surveillance and for stamping out reintroductions into the low prevalence and brucellosis free areas. In higher prevalence areas, surveillance costs are also high but the U.M.&R. do not provide sufficient positive incentives for individuals to take actions promoting control leading to local eradication.

Therefore: The Commission recommends consideration by the U.S.A.H.A., A.P.H.I.S., the States and various components of industry of proposed principles for a different approach to the U.M.&R. which address the deficiencies we have identified.

The goals of this proposal are: (1) to educate, by means of a warranty on all changes of ownership, the buyers, sellers and handlers of cattle, on the nature and extent of the risks involved in transfer of cattle. This warranty would be educational for a period of time, and

then with enabling legislation, have legal force; (2) to foster the assumption of individual responsibility and accountability for actions which tend to perpetuate and disseminate brucellosis. and to scimulate positive actions for effective control; (3) to establish criteria for classification of herds and states or regions which are based upon sound epidemiologic principles; (4) to apply these criteria so that resources may be used optimally to protect the 993 herds per thousand which are presently brucellosis-free from the risk of infection posed by the reservoir of 7 herds per thousand which are not; (5) to increase flexibility in meeting local and national needs by stimulating adoption of systems of individualized herd management which apply the best available technology to the specific epidemiologic situation; (6) to utilize presently available knowledge, as well as new information developing from research to increase resistance in herds and populations on a selective basis, and to limit spread of infection by rationally based movement and marketing constraints; (7) to develop and implement quality control standards for program performance and services.

11. Finding: Effectiveness, efficiency and cost of surveillance procedures are influenced both by long term trends in the cattle industry, such as change in herd size, geographic concentration of enterprises, and shorter term effects such as the phase of the beef cattle cycle or drought.

Finding: Any single method of surveillance is vulnerable to these changes in the dynamics of the cattle industry and may fail significantly in detecting infection under particular circumstances, as for example, during the accumulation phase of the beef cattle cycle when a smaller proportion of animals will pass through marketing channels.

Therefore: The Commission recommends that the MCI should not be used as the sole or primary method of surveillance, or for classification of states. Combined strategies of testing at slaughter, or change of ownership or movement, and post purchase testing should be keyed to prevailing conditions of marketing. Increased emphasis on timely and adequate epidemiologic follow up on surveillance test reports, including contact herd testing, and appropriate use of supplemental serologic tests, and culture where appropriate, are highly cost effective and should be extended.

In this section of our report we will use the original Charge to the Commission, set out in Section 3, as a framework, to indicate the questions which we addressed, and where, in the body of the report, the reader can find an extended treatment of specific aspects of our study.

As we followed the charge to review the concept of eradication of bovine brucellosis it became apparent, in our public hearings and in the position papers we received, that the semantic issue of the definition of eradication is a very real problem for various individuals and groups. Accordingly, we adopted a more precisely defined goal of local eradication of *Brucella abortus* from cattle, which has already been achieved in herds, states and regions of the United States, as well as in other countries, through the application of effective systems of control. This concept of local eradication is defined in Section 4.1, as part of a continuum resulting from individual actions, to actions involving many groups and larger areas, until it becomes national in scope. It is our judgement that this goal is biologically feasible and that local eradication of bovine brucellosis from the United States can be achieved, in the same sense that foot and mouth disease has been locally eradicated in North America. It is inherent in this definition, that continuing surveillance would be necessary to assure continued freedom from the disease, and that there be an emergency plan to prevent or to eliminate reintroductions.

In investigating the nature and present availability of knowledge essential to the goal of local eradication, we were able to draw upon the Report of the Subcommittee on Brucellosis Research of the National Academy of Sciences, and the Brucellosis Symposium of Texas A & M University. However, we made our own extensive literature review, especially with respect to infection rates, vaccine effects both under controlled conditions and in the field, and investigations on sensitivity and specificity of serologic and other diagnostic methods.

As documented in Section 4.4, we found that biologic information essential to the goal of local eradication is available. We also found that additional biologic information, is needed to accelerate the rate of progress through improved control, toward local eradication. This new information can be achieved only through continued biological research both on specific applied problems, and on other areas basic to an understanding of the disease. Specific issues related to research and research policy are discussed in Sections 4.4, 6, and 7.

Although it is clear that biologic knowledge essential to the goal is available, we were impressed at the extent to which important, well established facts about the disease and the program are not being distributed to those who need most to know. Furthermore, there has been a real failure to assume responsibility for adequate training and public

information programs on the part of those public agencies which should have a leadership role. These deficiencies of understanding became apparent in our field trips, public hearings, the position papers we received and from data collected in a study on information and attitudes of producers conducted for us. Data are presented in Appendix C, and the implications for policy are discussed in Sections 4.2, 4.6, 4.8 and 6.

The major conclusions to be drawn are that the lack of understanding of brucellosis and of the elements of the program are so general as to constitute a major barrier to the achievement of the goal of local eradication. Specific recommendations concerning educational and training programs are made in Sections 4.6 and 6.

In order to respond to the elements of the Charge on application of the eradication concept to the dynamics of the cattle industry, to evaluate program alternatives, and to make economic benefit/cost analyses of those alternatives, it was necessary to acquire and analyze various kinds of data, much of which had not been assembled before. We found that program data, as presently collected in the states, and compiled by APHIS staff do not provide an epidemiologic or administrative data base which is adequate for precise evaluation of program and performance. We have made specific recommendations in Sections 1 and 7 about this problem.

For our own work, it was necessary to collect and apply data and other information from several sources. In section 4.2 and 4.3 we summarized aspects of the structure, dynamics and marketing systems in the beef and dairy cattle industries. Particular attention was given to those aspects which have major impact on the policy options available, and on the epidemiology of bovine brucellosis. For example, superimposed on the most recent accumlation phase of the cattle cycle from 1965-76 there was a dramatic shift in the distribution of beef cow numbers, so that 65% of the increase in beef cow population occurred in 12 South Central and Southeastern states. Patterns of movement among states which influence spread of brucellosis are also discussed. Aspects of the dairy industry which influence spread and perpetuation of brucellosis include the decreasing number of dairy farms and cows and the increase in herd sizes. The health requirements, milk marketing and price support systems are discussed, as they have a major influence on policy decisions with respect to brucellosis.

For economic modeling, a special questionnaire on management practices and cost estimates was sent to 3935 beef producers and 4516 dairy producers, on which we received slightly better than a 30% return (Appendix B). Epidemiologic data were obtained, as described in Section 5, to be used in deriving coefficients for the benefit/cost analysis. These epidemiologic data were also of value in our examination of program policy options and program performance.

An in depth retrospective study was made of the brucellosis programs in 12 states from 1954-1976. Half of the states which were selected were "Certified Free" and half "Modified Certified". They were then matched, as far as possible, for such characteristics as numbers and types of cattle, geographic location, program procedures, expenditures, and timing. This study is presented in Appendix D. Several conclusions from it are summarized here:

(1) To make sufficient progress toward local eradication to be classified as "Modified Certified" it was necessary for states to make a sustained elevated rate of expenditure per cow at risk for four to six years, regardless of when the effort was begun. This increase in allocation of state resources, when matched with federal funds, apparently reflected sustained motivation and commitment to reach a goal which would either respond to milk marketing requirements, or to increase freedom of movement of cattle, or both.

(2) Once a state reached "Modified Certified" status expenditures declined in all states. However, the six states which did not proceed to "Certified Free" status clearly reduced their expenditures per cow at risk to a proportionately greater extent.

(3) Although program costs were reduced as states achieved "Certified Free" status, those states have been forced to maintain higher than normal surveillance costs, or even to make sharp increases in expenditures when reintroductions have occurred.

(4) In general terms, achievement of a relatively high rate of calfhood vaccination with Strain 19 in a state was associated with the achievement of "Certified Free" status, and a shorter interval between "modified" certification and certification as "free". However, there were exceptions, and no single plan to motivate adoption of vaccination could be recommended.

(5) Among other parameters of program performance monitored, one of the most significant appeared to be the outcomes of tracebacks to herds of origin of reactors in the MCI, both from first point of concentration testing or from slaughter sampling. Our interpretation of the data is that program performance in some states is inadequate to achieve control leading to local eradication.

(6) Survey of laboratory test procedures and results indicates that support, to assure quality of the laboratory procedures, backing up well trained epidemiologists and other field personnel, is inadequate. This is even more striking in relation to the large sums expended on indemnity payments, to identifying individual animals and collecting and processing blood samples in surveillance testing.

(7) Enforcement of compliance with regulations, both at the federal and state level does not seem to have much influence on program out-

comes, and does not appear to be cost effective.

With this background of specific data, it was possible for us to evaluate the present program (that is, the program in operation in 1975-76), the proposed U.S.D.A. "ten year accelerated program" and several modifications which seemed to be epidemiologically consistent and politically and economically feasible. The program alternatives were then tested in our systems simulation model, both to estimate probable outcome, and, to make an economic evaluation.

The state-federal cooperative brucellosis program operates under a set of minimum standards (U.M.&R.) for achieving and maintaining certification of herds and of areas. In addition each of the 50 states may enact legislation and regulations which impose additional standards which may be more rigorous than the minimum in the U.M.&R., and many states have done so. Thus there are, in effect, 50 individual programs. In the "Certified Free" states, the additional regulations are devised primarily with a view to prevent reintroductions from outside the state. The recent record indicates that with a persistent reservoir available, reintroductions do occur. The additional regulations also impose a significant economic cost, in the form of movement restrictions, particularly on the higher prevalence areas.

The process by which the U.M.&R. are modified is a political one in which attempts are made to accomodate to the needs and desires of various geographic and industry segments. This is discussed in Sections 4.7 and 6. Over the years, attempts to make these accomodations have resulted in trade offs of sound epidemiologic principles. Specifically, the present U.M.&R. promotes the transfer of responsibility and accountability for acting to prevent the spread of brucellosis away from individuals engaged in the livestock and marketing industries, to the federal and state regulatory agencies. In the process, it generates a false sense of security on the part of individuals who accept animals on the basis of rules which are epidemiologically invalid. It creates rewards for systems of evasion, thus promoting the maintenance and dissemination of bovine brucellosis.

Application of the present U.M.&R. results in continued very high costs, for surveillance, and for stamping out reintroductions of the disease into the low prevalence and brucellosis free areas. In higher prevelence areas, surveillance costs are also high but the U.M.&R. do not provide sufficient positive incentives for individuals to take actions promoting control leading to local eradication.

In our judgement, the 1975-76 program would establish an equilibrium which would move with the phases of the beef cattle cycle. While costly state and federal effort to increase efficiency of surveillance and level of compliance would probably result in additional states being certifed as "free", reintroductions would continue to occur. Also the

built-in deficiencies of surveillance and program performance in the higher prevalence regions would maintain infection there.

We considered a "control only" program option based upon attempts to achieve high level vaccination with Strain 19, with a moratorium on testing. This would be comparable to the strategy adopted in California between 1948 and 1957. We concluded that this would not be politically feasible, given the major investments which have been made over the past 10 to 25 years, by the "Certified Free" states, as well as those nearing that goal. This is discussed in Section 4. We also concluded that it was neither physically nor economically feasible to achieve the levels of vaccination which would be required to influence infection rates significantly over the nation as a whole. For these reasons the vaccination "control only" option was not modeled.

The "ten year accelerated eradication" program was examined and also subjected to systems simulation. On the basis of the coefficients derived from our epidemiologic data, we concluded that, with increased efficiency of detection as the sole major variable in this program, infection would still be present after the 10 year period, although, as described in Section 5 and Appendix B, the program would produce a net increase in benefits over the base program.

Other program alternatives were modeled in each of which a single variable involving vaccination in specific regions of the country were superimposed on the base program. As described in Section 5, the vaccination options were: increased use of Strain 19 calfhood vaccination, and extension of the practice of "whole herd" vaccination with reduced dosages of Strain 19, in the high prevalence regions. The "whole herd" vaccination strategy was based upon the recently developed data from field trials under the 1977 U.M.&R., which is discussed in Sections 4.4 and 7.

These program alternatives each produced substantial increases in benefits over the base program in the systems simulation, with the whole herd vaccination options producing the highest marginal benefit/cost ratios. In Section 5, we emphasize that, as is true for all models, our model contains many simplifying assumptions, and it should not be used as the sole basis for policy decisions. However, even if there were errors as high as plus or minus 50 percent, there is no question that the cooperative state-federal program as it existed in 1975-76 produced positive economic benefits, and that additional investment in improvement of that program would increase those benefits.

These considerations led us back to the defects we have tried to identify in the U.M.&R., and in operations under the 50 state-federal programs, in order to seek strategies which would more sharply focus efforts in achieving local eradication. As discussed in Sections 4, and 6 and in Appendix D, we feel that some of the major defects are: a shift of responsibility and accountability from producers, handlers and

the marketing sectors, to the government, inadequate knowledge about the disease and the program among those who have the greatest need to know, epidemiologically unsound regulations which generate mechanisms of evasion, a lack of high quality services to enhance the ability of individuals to develop flexible and specific programs to protect their own herds from infection, to free them of infection and to prevent dissemination of brucellosis. We therefore present in Section 6 a proposal for consideration of a different approach to the U.M.&R., which seeks to address these and other deficiences.

The Commission was also charged to consider the implications for the incidence of human brucellosis of the eradication concept, and of any proposed modifications. An extensive study is presented in Appendix A, and summarized briefly in Section 4.5. It is clear that the reported prevalence of human disease understates the true prevalence, and that as long as brucellosis exists in the cattle population there will be cases of brucellosis in people caused by Brucella abortus. In Sections 1 and 4.5 we call attention to the fact that this may result in the imposition of restrictions on slaughter of infected animals as a protective measure for occupational groups at high risk, and that even this would not address the problem of risk of infection faced by owners of infected livestock, their families and employees.

Section 3 History of the Commission and Charge

On invitation of Dr. F. J. Mulhern, Administrator of APHIS, Drs. D. T. Berman, W. T. Berry, Jr., John Hopkin, and W. W. Spink met with members of the APHIS staff in the U.S. Department of Agriculture Building in Washington, D.C. on February 12 and 13, 1976 to discuss the formation and charge of a Technical Commission to evaluate the National Brucellosis Eradication Program. Dr. R. K. Anderson was unable to attend but had agreed to serve. At that meeting, a proposed charge to the Commission, a time table for presentation of a report, and discussion of financing for the work of the Commission were all discussed.

Dr. Spink subsequently resigned from the Commission because of other commitments, and Dr. R. I. Wise was appointed. Dr. Berman was elected to serve as Chairman of the Commission. The charge accepted by the Commission is as follows:

The charge of the Brucellosis Technical Commission is to conduct a study of the national bovine brucellosis eradication program. The members of the Commission are nationally recognized experts in the fields of Agricultural Economics, Veterinary Medicine, Microbiology, and Public Health. They are charged to carry out the study and report their findings in a scientifically objective and independent manner. The end product should be free of bias or influence by industry, State, or Federal Agencies.

In the study, the Commission will:

1. Review the concept of eradication of bovine brucellosis in the United States, including the question of its ultimate feasibility. The review will include:

    a. An investigation of the nature and present availability of knowledge essential to the goal of eradication.

    b. Consideration of the circumstances and realities within which the eradication concept is to be applied, such as the breeding, management, and marketing practices of the cattle industry in various parts of the country.

    c. Examination of the implications for the incidence of human brucellosis of the eradication concept and any proposed modifications of it.

2. Review the program presently authorized by the statutes, as well as those projections under consideration. Con-

sider various technical and administrative alternatives which could provide for the ultimate goal of eradication. This consideration should address the questions of cost, acceptance by all parts of industry, as well as the potential effects on incidence of human brucellosis.

3. Make an economic benefit-cost analysis of the present program with its proposed extensions, and any other alternative programs the Commission deems appropriate.

In order to carry out this charge, the U.S. Department of Agriculture entered into contracts with the University of Wisconsin and with the Texas A & M University, with funding to begin on July 1, 1976, and the final report to be delivered by August 28, 1978.

Drs. Berman, Anderson and Berry met with the Brucellosis Committee of Livestock Conservation Institute in May, 1976 in Minneapolis.

Drs. Berman and Berry met with the Animal Health Committee of the American National Cattlemens Association on July 22, 1976 in Denver.

Drs. Berman, Anderson, Berry and Wise met with the National Academy of Sciences, National Research Council Committe on Health, Subcommittee on Brucellosis Research, at Reston, Virginia on June 10 and 11, 1976. At that meeting, the role of the Academy Committee in evaluating the research base for the National Brucellosis Eradication Program was discussed.

Drs. Berman and Berry attended the hearings before the Subcommittee on Department Operations, Investigations, and Oversight of the Committee on Agriculture of the House of Representatives in Washington, D.C., June 28, 29 and 30, 1976. Drs. Anderson and Hopkin attended the Symposium on Economic Analysis of Animal Disease Control and Eradication Programs, in Reading, England on July 10 through July 13, 1976.

Drs. Berman and Berry attended the Symposium on Brucellosis at College Station Texas, July 12-15, 1976, and participated there in discussions between representatives of livestock industry, regulatory officials, the National Academy Committee and members of the scientific research community.

The entire Commission conducted a public hearing in Miami Beach, Florida in connection with the U.S. Animal Health Association, November 10-18, 1976. The Commission members also interviewed U.S.D.A. APHIS regional epidemiologists and the Investigative Staff of the House Appropriations Committee at that meeting. Drs. Berry and Anderson made visits to dairy farms and beef cattle ranches in West Palm Beach, and Okeechobee County.

The Commission conducted a public hearing in Fresno, California in conjunction with the annual meeting of the California Cattlemen's

Association December 3, 1976. They also participated in the sessions of the Association devoted to brucellosis control and eradication. The Commission visited the Tulare regional brucellosis laboratory and a large infected dairy accompanied by a California Veterinary Medical Officer.

The Commission conducted a public hearing at Kansas City, MO, February 18, 1977.

The Commission conducted public hearings at College Station Texas on May 17, 1977 and at Tyler Texas on May 19, 1977 in connection with a work conference. Drs. Hopkin, Berry, Anderson and Berman visited quarantined or previously quarantined farms and ranches in the vicinity of Bryan, Palestine, Tyler, and DeKalb, Texas, accompanied by an APHIS epidemiologist and a Texas State Veterinary Medical Officer May, 19 and 20.

Other major meetings for collection of data or opinion of interested parties included:

Conference of Southern Regional Brucellosis Epidemiologists, Gainesville, Fla. attended by Drs. Anderson and Berman, March 14-19, 1977.

Meeting of the Brucellosis Committee of Livestock Conservation Institute, Columbus, Ohio, May 12, 1977. Attended by Dr. Berman.

Meeting of U.S. Animal Health Association, Minneapolis, Minn., October 16-21, 1977. Attended by entire Commission.

Meetings of Brucellosis research workers, Chicago, Illinois, November 28, 1976 and November 26, 1977. Attended by Drs. Anderson and Berman.

A list of all work conferences held, meetings attended and presentations made is given in Appendix F.

Position papers presented to the Commission with respect to the brucellosis program either at public hearings or in the mail were received from the individuals or organization listed in Appendix G.

In addition, the Commission had as major working documents: the Report of the Committee of Consultants on the Accelerated Brucellosis Control and Eradication Program, 1956, the Report of the Bovine Brucellosis Eradication Program in California, the Report of the Subcommittee on Brucellosis Research, of the Committee on Animal Health of the National Research Council, National Academy of Sciences, the transcripts of the hearings before the Subcommittee on Department Operations, Investigations, and Oversight of the Committee on Agriculture of the House of Representatives June 28, 29, and 30, 1976, and September 30,

October 1, 1977, the transcript of the hearings before the Subcommittee of the Committee of the House of Representatives of the 95th Congress, Subcommittee on Agriculture and Related Agencies, which includes the staff investigative report on brucellosis eradication, the Conference Report on the Agriculture and Related Agencies appropriation bill for 1978 report no. 95-520, the transcript of the special hearing before the Subcommittee on Agriculture and Related Agencies of the Senate Committee on Appropriations, 1976, the report entitled "Brucellosis Program Analysis" by Victor C. Beale, Jr. and Harvey A. Kryder, Jr., Veterinary Services, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, the Proceedings of the Symposium on Brucellosis held at Texas A & M University in July, 1976.

In addition, the Commission collected data by questionnaires from State Veterinarians in each of the 50 states, and from the Public Health Epidemiologists in each of the states. Detailed questionnaires requesting information on procurement and management practices, experience with herd infection and government programs relating to brucellosis were mailed to a random sample of dairy and beef cattle producers representing all regions of the United States. Moreover, interviews were conducted with a random sample of 150 producers in selected areas to assess producers' knowledge of brucellosis and the National Brucellosis Eradication Program and various factors which might be related to it.

The Commission solicited, and received comment from the members of the Brucellosis Committee of the U.S. Animal Health Association on a proposal by APHIS staff to modify the method of certification of areas. The Commission had copies of program reviews conducted in 10 high prevalence states during 1974. The Commission received copies of detailed comments from all regional epidemiologists and active brucellosis research workers on a series of policy issues relating to vaccination of calves and adult cattle, interpretation of diagnostic tests, retention of reactors in herds, quarantine standards, certification of areas.

An extensive questionnaire and direct telephone survey was made of Regional Epidemiologists, Station Epidemiologists, State Veterinarians or State program supervisors to collect data necessary for the derivation of coefficients for the benefit-cost model.

The Commission employed Dr. Hunt McCauley, Veterinary Economist to furnish estimates on economic losses.

The materials described serve as source material and the data base, along with other information in the general brucellosis epidemiology literature upon which both our program analysis, economic modeling efforts, and policy recommendations are based. The questionnaires and data summaries are appended to this report.

Section 4.1 Definitions of Control and Eradication

Much of the argument which has developed over the last decade with respect to the national brucellosis program centers on the semantic "eradication vs. control" issue without adequate definition of these terms by their respective proponents. Indeed, the Commission has been charged to "Review the concept of eradication of bovine brucellosis in the United States, including the question of its ultimate feasibility." We recognize that the existence of the semantic issue has also been used frequently to delay taking action of any kind. At the outset of its investigation the Commission decided that it was essential to adopt the following set of working definitions which define the issue more precisely:

In effect, all of the concepts under consideration can be regarded as being parts of a continuum involving reductions of prevalence of a disease. At one extreme, there would be no organized activity at all, and only natural forces would bear on the spread and prevalence of the disease. At the other extreme, global eradication means the complete disappearance of all sources of infection by a given disease agent, so that no recurrence of that disease is possible, even in the absence of all preventive measures, including surveillance. It has been claimed that human smallpox has been eradicated from the globe, but surveillance is being continued in order to determine the validity of that claim.

The Commission has concluded that it is not useful to pursue further these extremes of the continuum. Within our planning horizons, global eradication of brucellosis is certainly not socially or politically feasible, probably not technically feasible, regardless of whether or not it might biologically feasible, as is the case with smallpox. Neither is it feasible to revert to a process of no organized control at all.

As we define them, control and eradication are on a continuum of actions applied to local units. Local control would mean the reduction of prevalence of the disease to the point where the costs equal the benefits as perceived by the decision makers for each local unit. The local unit could be the individual herd, and its owner, might be concerned only with prevention of abortion on his farm. He might perceive any control costs beyond those necessary to achieve his limited objective to be excessive. The geographic dimensions of his concern would be broadened considerably, as was the case for most dairy farmers when, in 1955, their milk markets required eradication of brucellosis from their herds. Under such conditions, control extends to a broader community and involves more decision makers, and more perceptions both of the benefits and of the costs of the control program.

It is implicit in this concept, that with local control the sources

of infection remain present, and measures to maintain prevalence of the disease at a level in which all perceived costs do not exceed the benefits will be ongoing indefinitely. Also, under those circumstances the costs will not be borne equally by all.

If local control is sufficiently effective it can result in local eradication. Local eradication indicates the elimination of all sources of infection from a given area, so that the disease does not recur unless it is reintroduced from outside the area. Again, it is possible to speak of local eradication of bovine brucellosis from the individual herd, from groups of herds, communities, states, and so on. The status of local eradication implies a continuing effective system of surveillance in order to detect reintroductions from outside the area, as well as assurance that secondary spread is not occurring. In this context, control and eradication are part of a continuum from individual action for control, through organized programs of control, involving geographical areas of increasing size and increasing degrees of effectiveness, which produce reductions of prevalence--that is to say local eradication of larger and larger areas--until it becomes national in scope. It is implicit in this working definition that in areas of relatively moderate to high prevalence, local eradication of bovine brucellosis as an ultimate goal is reasonable, only if truly effective control is being achieved within the locality.

So far, these definitions of local control and local eradication have treated the situation as if they were limited geographically only. In fact, control and local eradication of bovine brucellosis must take into account facts such as that there are more than one species of Brucella organisms, and more than the bovine species as potential or actual hosts of these organisms. For example, when it was common agricultural practice to have swine follow cattle in feedlots, B. abortus could be isolated frequently from the tissues of the swine. Whether or not they had a significant part in transmission to cattle is not known. Similarly, in those parts of the world where B. melitensis infection is common in sheep and goats, cattle are also frequently infected with B. melitensis. Control or eradication programs directed only at the cattle population would be doomed to failure in those parts of the world. It is unrealistic to make policy decisions for the mountain states which do not take into consideration the occurrence of self perpetuating B. abortus infection of part of the elk population. Experience also tells us that it is possible to prevent transmission between the elk and cattle, and that local eradication of the disease from cattle is feasible.

Within the framework of these definitions, it is clear that local eradication has been achieved for a large number of animal diseases. For example, we can consider foot and mouth disease to have been locally eradicated from the North American continent. It exists, of course, in many other parts of the world and could be reintroduced at any time there are significant failures of the preventive measures taken to prevent its reintroduction. Furthermore, the decision makers perceive

the benefits of maintaining this condition of local eradication of foot and mouth disease to outweigh the considerable costs of our surveillance and quarantine program.

In the same terms of reference, the biological and technological feasibility of local eradication of bovine brucellosis has been demonstrated in many places. The Scandinavian countries have been free of brucellosis since 1962. Iceland, Switzerland, Luxembourg, Israel, Japan, Tasmania, among others, enjoy this status. When bovine brucellosis has occurred in those countries, it has been reintroduced from outside sources.

It is significant that in most of the developed countries, which presently have a higher overall prevalence of infection than exists in the U.S.A., national eradication remains the goal and target dates have been set to achieve it. To illustrate this point, the estimated national prevalence rate for 1975 in the U.S.A. was approximately 0.8% of the breeding age cattle. In Australia, the comparable figure was 2.3%. A reasonable estimate of the overall herd infection rate in the U.S.A. in 1975 was 0.7% of the estimated population of 1,755,654 herds, with a range of 0 for small states such as Maine to a maximum of approximately 2.5%, in Florida. In England and Wales, the comparable figure was approximately 16% of the approximately 150,000 herds, and their target date for national eradication is 1980.

Local eradication of bovine brucellosis has also been achieved in many of the "Certified Free States." Thus, all internal sources of infection had been eliminated in Maine, Vermont and New York, and the disease did not recur until it was reintroduced by imported Canadian cattle into Vermont and New York in 1976. Secondary spread occurred in those states during 1977 and is just now being brought back under control. The options available to the decision makers were to balance a relatively low immediate level of expenditures on a control program, which would probably maintain infection at the levels experienced during 1976-78, against higher short term costs of a program which would again achieve local eradication. Their planning necessarily included a determination that ongoing costs of a control program would continue indefinitely. In both states, the decision was that the benefits of eradication outweighed the costs. Between January and November, 1977 added eradication costs in New York State were estimated to be $2 million. (Nadler, H. E., Bovine disease control problems in the Northeast. Brucellosis: An overview, Cornell Vet. 68, 164-172, 1978). In order to provide direct assistance to those cattle owners directly affected, New York State increased indemnity payments for reactors to more adequately reflect their replacement costs.

Having established and illustrated these working definitions, the Commission believes that its charge can best be stated in terms either of programs of control which would be ongoing, in order to maintain levels of prevalence sufficiently low as to balance presently perceived

costs and benefits, or of control programs of increasing levels of intensitity leading to local eradication which is national in scope. Identification and analysis of the positive and negative factors, or constraints, which determine the decision to choose between control and control leading to eradication is essential to this process.

In this section of our report, we have identified biological constraints, constraints of levels of understanding of the problem among decision makers, and variations among them of planning horizons. There are constraints imposed by the nature of the cattle industries, which are not identical for the beef and dairy cattle industries, nor are they identical in all parts of the country within either of those industries. There are public health, political, legal, economic, sociological and cultural factors all of which impinge on the decision to choose among the two alternative courses of action. A systematic analysis follows.

Section 4.2 THE NATURE AND STRUCTURE OF THE BEEF CATTLE INDUSTRY

General Information

Raising cattle is a difficult and risky business. Small farmers and ranchers, part-time operators, dairymen, large ranchers (some corporate), and large and small feedlot operators are the country's cattle raisers. In 1977 there were 1,788,740 farms reporting beef cattle and 403,410 farms reporting dairy cattle (Table 1). Clearly, cattle-raising has been and remains one of the most widely dispersed and diverse of all farming enterprises (Fig. 1).

Cattle and calves are raised and fed for meat and milk in every state. On January 1, 1975 there were a record 132 million cattle on U.S. farms and ranches, 35 million head more than on January 1, 1955 (Table 2). Regional distribution of cattle production changed somewhat during those years, influenced both by the decline in dairy cow numbers, (Fig. 2) and the increase in large cattle feedlots (Table 3).

Sales of cattle and calves from all farms and ranches totaled $18 billion in 1975, or one-fifth of total cash receipts from farm marketing of all livestock products and crops (Table 4). Texas and Iowa usually lead in cash income from cattle, with receipts in Texas consistently running over $2 billion a year from marketings of cattle and calves.

In many other states, cash receipts from sales of cattle and calves rank first among sales of all farm commodities. In addition to Texas and Iowa, this is usually true in Arizona, California, Colorado, Nebraska, Nevada, New Mexico, Oklahoma, South Dakota, Utah, West Virginia, and Wyoming.

Topography, historical development of the dairy industry in certain states, a lack of alternative farming possibilities in some areas, and availability of feed grains account for much of the concentration of cattle-raising in certain parts of the U.S. Cattle-raising, based on breeding cow herds, remains fragmented among many producers with diverse operations. Cattle-feeding, however, has become increasingly concentrated since 1950, and especially since 1960.

Since 1950, beef production has increased in all regions, but the Southeast has increased its herds most rapidly, as shown in Table 5. The traditional cattle and range areas of the Northern Plains, Mountains, and Southwest now have a smaller share of the cow and calf population than in 1950 -- 50% now compared with 64% in 1950 -- although beef cow numbers have also grown in all regions the past 25 years, associated to some degree with the decline in milk cow numbers.

Some small cattle feeders have a beef cow herd to supply their own cattle for fattening, to utilize both the roughage and the grain grown

on the farm. Other farmers find cattle-raising fits in well with working at a non-farm job. The number of part-time farmers in the U.S. has increased rapidly since 1960, and there is a greater proportion of such operators in the South than in the West. Many of them have relatively low land and livestock debts and thus tend to stay in production even when cattle prices are low.

Many of the roughly one-half million farmers selling less than $2,500 worth of farm products, including some cattle, are families who live on the farm for privacy or for sentimental reasons. They have already incurred much of the cost of cattle-raising as a part of their living costs, so the additional cost of cattle production is not great. This tends to keep them in production even when cattle prices are low relative to cost of feed and other supplies. Since there is less at stake in these small farming and part-time operations, the health programs are often neglected, the operators are not acquainted with disease control programs, and this break in the chain of control must be recognized and allowances made in the education, surveillance, and regulatory programs.

In the period 1965-1976 there was a dramatic shift in beef cow numbers in the U.S. with 65% of the increase occurring in 12 states: Kansas, Oklahoma, Texas, Missouri, Arkansas, Louisiana, Kentucky, Tennessee, Alabama, Mississippi, Georgia, and Florida. In 1975 the U.S. beef cow inventory was 45 million head and there were 25 million beef cows in the 12 states listed above which represented 55% of the U.S. total (Table 6).

This big increase in beef cows in the southern and southeastern states was the result of (1) a shift from dairy cows to beef production, (2) conversion of many farm operations from cash crops to grass, and (3) favorable weather conditions in the high rainfall belt. In these same 12 states the incidence of Brucellosis increased right along with the increase in cattle numbers (Table 7, Fig. 3).

In many cases during this last rapid expansion period the cattlemen in the same 12-state area were new in the business, had a lot to learn, and started "put-together" cow herds and in doing so bought other people's disease problems. In the recent cattle depression many of these new, inexperienced, and unsuccessful cow-calf operators have sold out.

During the herd-rebuilding process which is now underway, most of the increase will be in established herds rather than newly-created herds that occurred previously. Those that remain have come through tough times and will probably remain in business and should be able to profit from their past experiences. They should have a better knowledge and appreciation of the objectives and procedures necessary for a brucellosis control program and should fully and enthusiastically support progressive and aggressive brucellosis control programs. However, it

would be a mistake to assume that they will, and well designed and targeted education programs at the local level are essential during the period of time when they will be rebuilding herds.

STRUCTURE OF THE CATTLE BUSINESS

There are three principal phases of the commercial cattle business: cow-calf, stocker, and feeder. The registered beef breeder is a specialist. The packer must also be included in any brucellosis control program considerations.

Commercial Cow-Calf Operations

There are approximately 40 million commercial beef cows in the U.S. and approximately 1,800,000 cattlemen. Some of these commercial cattlemen have integrated programs involving all phases of the beef industry, while others are involved in only two phases. The usual case, however, is that each cattleman is basically involved in only one phase and sells his animals to the next specialist.

The long chain of beef production leading to the consumer's table begins with cow-calf operations of various sizes all over the U.S. Generally speaking, calves are marketed through public livestock auction, terminal markets, or directly from farmer or rancher or another cattleman. The calves are generally handled in one of three ways: as feeder calves for handling in feedlots, directly to packers as slaughter calves, or as stockers for further growth on grass or forage for breeding or eventual movement to feedlot and slaughter. The production process in the cow-calf operation is highly seasonal, as most cows are bred to calve in the spring, and graze during summer months when grass is available. Hence, 50% or more of all feeder calves in the U.S. are marketed during the fall or early winter months each year.

The cow-calf operator traditionally uses the maximum carrying capacity on his farm or ranch for the cow herd, and at weaning sells all the calves except his replacement heifers. His annual cash income is from the sale of all of his steer calves, about one-half of his heifer calves, and about 15-20% of his cows and bulls which are culled.

The larger cow-calf operators develop a market for their calves and, as a general rule, sell to the same geographical area and to the same group of buyers over a period of years. Their breeding program is such that they can represent the calves to perform in a certain manner and the regular buyers become accustomed to expecting certain performance from the purchased calves.

There are literally hundreds of thousands of small operators, however, who do not have enough animals to attract buyers' interest at

their farm or ranch, so they sell to auction markets, where the animals are professionally sorted and grouped for uniformity to maximize buyer-interest and price, or, they sell to local traders who "make the rounds" on a regular basis purchasing calves on the farm and grouping them for later sale. In either case, small groups of steer and heifer calves, from many sources, under these production conditions, lose their identities and any information about their previous treatment and/or exposure to disease is unknown.

The allocation of the calf crop among the above alternatives is in response to price bidding among cattle feeders, slaughtering firms, or stockers and growers. The prices paid depend largely on the current and anticipated market demand for fed beef versus non-fed beef, and the cost of resources needed for further growing out or fattening cattle. The market system in an open economy allocates feeder calves, feed grain, etc., to their most valuable end use, that is to the highest bidder. Thus, when consumers are willing to pay relatively high prices for fed beef and grain prices are relatively low, cattle feeders will outbid other farmers and ranchers and slaughtering firms for young cattle.

Conversely, when feed grain prices are high in relation to their value in fattening cattle, feedlot operators bid less agressively for young cattle. As a result a higher proportion of potential feeder cattle are channeled directly to slaughter as non-fed beef or to stocker and grower pastures. Each of these alternatives directly affects cattle movement and thus impacts upon brucellosis control.

Stocker Operator

Regardless of the method of sale a very high percentage of the steer calves and about one third of all the heifer calves produced each year wind up in the ownership of stocker operators. They are specialists, owning the cattle from weaning to the yearling stage of life. The objective of the stocker operator is to grow frame, muscle, and vital organs in the most economical way to prepare feeders for finishing in the feedlot or growing replacement heifers as future breeder cows.

The stocker animals are fed every conceivable type of roughage, and grazed on every conceivable type of forage. It will vary from native range, to stalk fields, to fertilized highly-improved pastures. The performance (growth and gain) of the calves is just as variable as the types of forage and grazing conditions.

It is noteworthy that most of the growth of stocker cattle, steers and heifers, is developed in a transient stage either on owned or leased land used seasonally. Good management dictates that the cattle must move on when the land is grazed off or the roughage is consumed. This further contributes to the ongoing movement of cattle.

Much of the movement of stocker cattle is interstate. There are

traditional movement patterns but these frequently are interrupted, changed, or modified as influenced by weather, prices, and trends in the cattle cycle. Each year is different and thus brucellosis surveillance programs to be effective must be flexible to accommodate the wide variability in stocker movement.

Feedlots

Feedlot operators are also specialists. As a general rule they take 600-800 feeders (steers and heifers) and feed them from a period of from 100-180 days and the finished cattle are sold to packers for slaughter.

Before grain prices abruptly rose in the early 70's many lightweight feeder calves, both steers and heifers, weighing about 350500 pounds were placed on feed and fed for more than 200 days to slaughter weight. In those days the cost of gains in the feedlot were comparable to, or even cheaper than, some grass gains.

In 1973-78 cost of gains was too high for prolonged feeding, so the average time in the feedyards was drastically reduced and heifers stayed on grass longer.

When the demand for heifer calves is greater than the supply there is a tendency for some heifers to be re-allocated to breeding programs after they have already been committed to a grazing-growing program or have been placed in the feedlot for fattening. It seems that unthrifty and unattractive heifer calves begin to mend and look better as breeding animals after they have had good nutrition for several weeks. In some instances they are removed from the feedyard to a ranch for breeding (Fig. 4) -- thus brucellosis vaccination status and blood testing become a consideration. In other instances, while on grass, they too are selected as breeding animals and moved into a breeding herd with the same brucellosis considerations. As long as a reservoir of brucellosis exists, this type of movement and mixing carries with it the risk of transmission.

This situation does not occur when there is an abundance of calves and producers can be more selective and critical in their selection of replacement females. But, calves are scarce in 1978 and will continue to be for the next two or three years in the present expansion phase of the cattle cycle.

In many instances the heifers selected out of feedlots or off grass and placed in breeding herds come from a variety of sources with no past records. In nearly all cases they have not been calfhood-vaccinated and in some instances those that are vaccinated have been done so carelessly and have questionable immunity when compared with calves properly handled.

Registered Cattle Breeders

Registered breeders are a very special group with about 1.5 million cows in their herds representing approximately 3.5% of the total cow inventory. Registered breeders produce seedstock for the commercial beef industry. They keep accurate pedigree records on all animals to qualify for registration in their respective breed associations. All animals are individually identified so that all individual records and performance and progeny data gathered about each animal can be permanently recorded.

Registered beef cattle are marketed at public auction, private herd auction, and by private treaty sale. They will average selling for about three times the average price of commercial cattle. About 75% of a registered herd's production goes for breeding purposes and the rest sell by the pound the same as commercial cattle.

A large percentage of the sales and shipments are interstate and there are also some foreign sales. Since registered animals are more valuable than commercial cattle any delays and restrictions in marketing are very costly to the owners. As insurance against such losses and to protect their freedom of marketing nearly all registered breeders have a strain 19 calfhood vaccination program and carry out annual herd certification testing to maintain a free status. These practices guarantee a quick preparation of health papers for immediate sale and shipment.

The purebred breeder in a high-prevalence area is in a particularly risky situation, even if he carries out his own local eradication program and protects his animals with vaccination. Neighborhood-spread does occur and no vaccine is perfect. He wants local eradication to include not only his own herd and immediate neighbors, but whatever serves as a potential source of infection in his operation.

Vaccination can also pose problems. Some potential markets for purebred cattle, such as West Germany and other European countries, ban strain 19 vaccination of imports. This, obviously, poses a problem for the purebred breeder. From his standpoint, he wants control leading to local eradication so he will not have to vaccinate in the future.

The purebred breeder who vaccinates and markets cows through an auction will, from time to time, have a card test reactor which imposes problems for him unless it is rapidly sorted out with supplemental testing. If local eradication were extensive enough, he could consider not vaccinating and remove this uncertainty from his operation. This is the situation for purebred breeders in say, Pennsylvania. Of course, if there is a re-introduction, they have a real problem.

The registered breeder is really caught in a dilemma. The high prices for his animals mean that as long as his animals are free of bru-

cellosis he will be for eradication. But when his herd becomes infected, he will want to preserve bloodlines and will be a strong supporter of control measures, which might permit him to retain reactors.

Packing Plants

Packing plants are another essential link in the beef market process, converting cattle into dressed carcass beef. There are trends in the packing industry which have an effect on the brucellosis program. This primarily lies in the size and number of the packing plants with which a brucellosis program will be involved through the slaughter sample surveillance system, and in the accounting for branded reactors for indemnity claims (Tables 8 and 9).

CATTLE ON WHEELS

It is obvious from the previous discussions that the U.S. beef industry is literally on wheels. Cattle of all ages and types are moved to the next phase of production on a seasonal basis to take advantage of available and cheaper grass, cheaper and more abundant supply of grain, and more favorable weather. Table 10 and Figs 5-10 all serve to illustrate the staggering number of cattle that are transported each year. Such movement means gathering, sorting, re-sorting, exposure to disease, and hence disease-spread.

Movement of feeder cattle in the U.S. has changed dramatically during the past 40 years, primarily because of the changes in locations of calf production, intensification of feeding operations, and the geographic concentration of the cattle feeding industry. Completion of the interstate highway system and vast improvement of trucking facilities has virtually halted rail movement of feeder cattle, allowing greater flexibility in direction of shipment as market conditions change.

Historically, Iowa and surrounding states dominated the cattle feeding industry. The primary movement of feeder cattle was from Western, Southwestern, and mountain ranges to the Corn Belt. Surplus grain supplies and a location near slaughter plants that lay on the route to population centers gave this area a substantial feeding advantage.

Things have changed in recent years. With dairy herds reduced as a percentage of the total cow herd, beef herds are by far the principal source of feeder calves and yearlings. The development of feed grain production in the Southwest accelerated the expansion of cattle feeding in the Southern Plains in the 60's and early 70's. The Southeast has become a principal calf producer -- thus feeder cattle movement has been altered significantly to the present pattern shown in Fig. 10. This newer pattern of movement, as well as the practices described on p 4.2-5 favor reintroductions of brucellosis into areas which have become almost

free or certified free. This fact accounts for a significant part of the high costs for surveillance still incurred in the North Central and Western importing states.

By using beef cow numbers and distribution (Fig. 11), and the location of cattle feeding as a guide to feeder cattle movement (Fig. 12) we visualize a clockwise movement of feeder cattle in the U.S. as shown in Fig. 10.

Feeder cattle from the Southwest move primarily into the Southern Plains and Far West and the Eastern Corn Belt. Cattle from the Northern Plains and Western Ranges still move into the Corn Belt, but some also go to feedlots in the Central Plains. Most of the feeder cattle raised in the Plains states are placed in feedlots there. However, feeder cattle move in almost any direction at a given time in response to differences in demand—for weights, grades, or type of cattle preferred by feedlot operators, or for slaughter as non-fed beef, when feeding to higher grades is unprofitable.

The number of cattle sold each year is usually 2.0 to 2.2 times as great as the number of cattle slaughtered, or approximately 100 million head per year. Calves and feeder cattle are often sold from farm to farm three to five times during a short life of 2 years.

CATTLE CYCLE

From the foregoing discussions it is obvious that the structure of the beef cattle industry is very fragmented with a substantial number of barriers to the effective control of brucellosis. These barriers are further complicated by the cattle cycle which is a well-identified phenomenon within American agriculture. It consists of alternate increases and declines in total cattle numbers. Since World War II it has shown considerable regularity in terms of duration and internal workings.

The cattle cycle is sometimes reported as a cycle in average prices received by farmers for cattle, while at other times it is identified as a cycle in inventory numbers of cattle. The two are related, and whether one starts with prices or numbers, it is clear that cyclical trends in inventories, slaughter levels, and prices are all closely linked, with the latter two being inversely related.

There exists a well-defined, long-term, upward trend in beef cattle numbers. Figure 13 shows the secular trend in numbers and also shows the so-called "cattle cycle" with a frequency of approximately 10 years between peaks. An analysis of prior cattle cycles can be very useful in predicting cattle movement. Brucellosis control programs can take advantage of the cycle.

Up to now cattle cycles have been impressively uniform in their general pattern and length of duration. In the expansion phase of each cycle there is a relative shortage of calves with more demand than the cow herd can produce. Conversely, during sell-off phase of the cycle, losses in merchandising, slaughter, and feeding are passed back to the cow-calf operators.

In the real world there are several factors which complicate adjustments in the cattle cycle. First, every head of cattle on hand in the inventory can be considered as either a producer of more beef, or as a potential consumer product at any particular moment. The animal either may be kept in the breeding herd, on pasture, or in the feedlot. It can continue to produce calves or to grow in weight and thereby produce beef; or it can be shipped to the market immediately and become available for consumption.

It is the hundreds of thousands of producers who own the cattle who daily make decisions whether to keep their animals for further production, or to send them to market. These crucial decisions are strongly influenced by how these producers interpret movements in cattle prices. If, on the one hand, they view a sudden price rise as temporary, they will respond by shipping animals to market, increasing beef supplies in the short run, and tending to decrease future supplies of beef, since an increased number of breeding and feeder animals will have been slaughtered.

On the other hand, if most producers interpret a price increase as signaling a long-range rise in cattle prices, they would respond by holding back animals from slaughter, and increasing breeding herds and numbers of cattle on feed. This appears to be the situation which caused cattle prices to rise rapidly in the first half of 1978.

The persistency and regularity of the cattle cycle (numbers) attests to the tendency on the part of cattlemen -- farmers, ranchers, feeders, -- to over-correct beef supplies, with resulting cyclical swings in prices. The time required to complete the cattle cycle has declined over the years, from about 16 years for the first few cycles to about 10 years for the last three.

It still requires about six years to complete the expansion phase of the cycle, after cattlemen are convinced that cattle prices justify the expansion. This period of time required for the expansion phase to occur seems to have remained constant throughout this century. However, the length of the liquidation has declined from nearly eight years for the first three cycles, to three to four years for the last three cycles.

One reason for this reduction is the increased effectiveness of information systems serving farmers and ranchers and the increased capacity and willingness of the cattle industry to respond to this informa-

tion. Structuring a brucellosis control program with sufficient funds available at the right time for maximum effectiveness must be tied in with the cattle cycle.

Cattle numbers are dependent on two crucial decisions made annually by cattlemen: (1) the number of cows to cull from the breeding herd and (2) the number of raised heifers to maintain for breeding herd replacements. These important decisions are primarily influenced by calf prices.

In the last four cycles, the buildup phase has had the following characteristics: (1) the culling rates were reduced, (2) more heifers were retained, and (3) cattle numbers increased. At present the national cow herd is young, primarily because a very high percentage of older cows were culled in the liquidation phase beginning in 1974.

In the most recent cycle there were several specific differences in the Southeast, compared with other regions. The Southeast was slower to begin the liquidation phase, lagging approximately two years behind the Western States. During the second half of 1973 and in the first half of 1974 the first response of Southern cattle owners was to hold cattle for higher prices. This was reflected in less market surveillance in the 1974 fiscal year and fewer infected herds detected and quarantined.

It appears that the cycle has just about reached the bottom of the liquidation phase in 1978 and the accumulation phase has already begun, particularly in the West, and is likely to continue during the next four to five years. The production and marketing procedures characteristic of this phase of the cycle are likely to result in increased prevalence of infection because of deficiencies inherent in the surveillance system, the type of movement, and the increase in movement of cattle caused by current market conditions.

Because the accumulation phase of the next cycle is underway, the culling rate for the next several years is likely to be lower. A higher than normal number of heifer calves will be retained for breeding purposes, there will be relatively smaller numbers of calves available for feedlots, and the price of calves will be significantly higher. A greater demand for cows for breeding purposes at higher prices is already established and this is likely to increase.

The movement of females is more likely to be directly between the farms and ranches for breeding purposes and less likely to be to slaughter. The surveillance system based upon slaughter sampling or testing at the market will sample a significantly smaller part of the female population (Table 11).

There is already vigorous competition between cow-calf operators and feedlot operators for heifer calves, and many of them will get into the hands of speculators anticipating further rise in female stock for

breeding purposes. The heifer calves will be "two-way" cattle and their final destination will be difficult to predict. The best guess is that many scheduled for the feedlot will wind up in breeding herds scattered across the country.

This accumulation phase of the cattle cycle would be the ideal time to build the maximum level of strain 19 vaccine-induced protection into the female cattle population. If new breeding heifers are moving into already infected herds, they should have vaccinal protection in order to minimize the extremely high probability of them becoming infected during their first pregnancy, with the attendant major economic loss from abortion and increase in the exposure potential.

If they are moving through multiple hands, into presently uninfected herds, they should have vaccinal protection so as to minimize the opportunity of becoming infected in transit, and seeding down a previously uninfected herd. All indications are that vaccinated heifers are not available in any significant numbers, and yet, given the high price that heifers are bringing in the market, the premium which vaccination can command is a relatively small percentage of the total price.

Table 1

NUMBER OF OPERATIONS WITH CATTLE AND MILK COWS, 1975-77

STATE	OPERATIONS WITH CATTLE			OPERATIONS WITH MILK COWS 1/		
	1975	1976	1977	1975	1976	1977
	NUMBER					
ALA	54000	53000	52000	7000	7000	7000
ALAS	140	140	140	60	60	60
ARIZ	3500	3800	3900	950	1000	970
ARK	52000	54000	54000	8000	8000	8000
CALIF	27000	28000	29000	6000	6000	5900
COLO	19500	20000	19400	4700	4600	4500
CONN	2200	2200	2200	1200	1200	1200
DEL	1000	1000	900	400	350	330
FLA	22000	21000	21000	3200	3200	3100
GA	46000	46000	46000	5000	4000	4000
HAW	930	900	900	100	80	80
IDAHO	19000	18500	19000	5800	5400	5200
ILL	62000	61000	60000	10000	9000	9000
IND	56000	55000	53000	10500	10000	9200
IOWA	96000	92000	88000	19000	19000	17500
KANS	57000	57000	56000	8000	7500	7000
KY	90000	87000	85000	25000	24000	22000
LA	37000	35000	33000	8000	7500	6500
MAINE	3900	3900	3900	2200	2200	2200
MD	8200	8100	8000	4200	4100	4100
MASS	2300	2300	2300	1400	1400	1400
MICH	36000	35000	34000	12000	11000	10500
MINN	75000	73000	71000	34000	31000	29000
MISS	62000	60000	58000	8500	8000	7300
MO	115000	113000	111000	21000	20000	19000
MONT	18000	18000	17800	4400	4300	4200
NEBR	56000	53000	52000	8500	7500	7000
NEV	1500	1500	1500	400	450	400
N H	1700	1700	1700	1000	900	900
N J	2600	2600	2600	1000	900	900
N MEX	8500	8500	8500	1800	1800	1800
N Y	37000	36000	35000	21500	21000	20500
N C	53000	54000	51000	11000	11000	10000
N DAK	26000	24500	24000	7000	6000	5500
OHIO	62000	60000	58000	14800	14100	13600
OKLA	73000	73000	71000	8000	7500	7000
OREG	23000	23500	23000	4800	4800	4800
PA	52000	52000	52000	25000	24000	24000
R I	300	300	300	170	170	170
S C	22000	23500	22500	3700	3600	3300
S DAK	35000	34000	34000	9200	8600	8600
TENN	88000	85000	79000	18000	15000	13000
TEX	165000	165000	160000	15000	14500	14000
UTAH	10000	10000	10000	2800	2700	2700
VT	5300	5200	5200	4500	4500	4500
VA	42000	40000	39000	13000	12000	11000
WASH	22500	22000	21500	5000	4700	4400
W VA	20000	20000	19800	5600	5500	5200
WIS	87000	84000	81000	53000	51000	49000
WYO	6900	6800	6700	2000	1900	1900
U.S.	1865970	1834940	1788740	447380	424010	403410

1/ INCLUDED IN OPERATIONS WITH CATTLE

Table 2

Cattle and Calves: Total Number and All Cows
January 1, 1975-76

State	All Cattle and Calves			All Cows That Have Calved		
	1975	1976	1976 as % of 75	1975	1976	1976 as % of 75
	1,000 Head		Percent	1,000 Head		Percent
Ala.	2700	2850	106	1330	1400	105
Alas.	9.3	8.5	91	4.4	4.1	93
Ariz.	1170	1280	109	436	380	87
Ark.	2680	2385	89	1350	1274	94
Calif.	5200	5000	96	1897	1820	96
Colo.	3375	3250	96	1125	1115	99
Conn.	110	110	100	62	61	98
Del.	33	33	100	18	18	100
Fla.	2950	2920	99	1670	1615	97
Ga.	2420	2370	98	1190	1166	98
Haw.	250	245	98	106	103	97
Idaho	2150	1875	87	870	780	90
Ill.	3200	3400	106	1125	1086	97
Ind.	2125	2225	105	802	830	103
Iowa	7350	7500	102	2240	2323	104
Kans.	6400	6450	101	2125	1900	89
Ky.	3750	3450	92	1725	1650	96
La.	1832	1880	103	1043	1090	105
Maine	138	141	102	72	72	100
Md.	444	460	104	207	220	106
Mass.	107	107	100	63	64	102
Mich.	1640	1650	101	620	616	99
Minn.	4430	4430	100	1625	1641	101
Miss.	3000	2723	91	1584	1434	91
Mo.	6800	6600	97	3070	3000	98
Mont.	3340	3150	94	1720	1640	95
Nebr.	6900	6550	95	2530	2290	91
Nev.	657	651	99	352	350	99
N.H.	71	72	101	38	39	103
N.J.	117	110	94	62	59	95
N. Mex.	1720	1650	96	745	675	91
N.Y.	1875	1915	102	1045	1046	100
N.C.	1120	1130	101	568	578	102
N. Dak.	2635	2380	90	1358	1269	93
Ohio	2350	2305	98	850	890	105
Okla.	6500	6400	98	2835	2790	98
Ore.	1470	1440	98	708	710	100

Table 2

State	All Cattle and Calves			All Cows That Have Calved		
	1975	1976	1976 as % of 75	1975	1976	1976 as % of 75
Pa.	1960	1960	100	862	914	106
R.I.	12	12	100	7	7	100
S.C.	710	725	102	364	368	101
S. Dak.	4950	4500	91	2290	2061	90
Tenn.	3300	3100	94	1510	1480	98
Texas	16600	15600	94	7240	6800	94
Utah	900	927	103	428	441	103
Vt.	336	346	103	206	208	101
Va.	1750	1650	94	780	780	100
Wash.	1420	1375	97	584	572	98
W. Va.	540	555	103	267	283	106
Wisc.	4640	4550	98	2155	2162	100
Wyo.	1690	1580	93	819	760	93
U. S.	131826	127976	97	56682	54834	97

Source: Cattle, February, 1976, P. 5.

Table 3

Number of Cattle Feedlots and Fed Cattle Marketed, 1976-77

	1976		1977	
State	Number Lots	Cattle Marketed (1,000 head)	Number Lots	Cattle Marketed (1,000 head)
Arizona	48	795	41	646
California	150	1,844	137	1,612
Colorado	502	2,134	506	2,301
Idaho	563	340	544	438
Illinois	14,000	935	14,000	940
Indiana	10,500	365	10,500	352
Iowa	33,000	2,905	33,000	2,862
Kansas	6,000	3,084	6,000	3,287
Michigan	1,600	271	1,550	277
Minnesota	11,200	804	11,200	758
Missouri	8,000	346	8,000	323
Montana	119	104	101	134
Nebraska	14,550	3,458	14,360	3,785
New Mexico	40	306	40	294
North Dakota	900	71	898	63
Ohio	7,800	387	7,800	403
Oklahoma	355	678	360	732
Oregon	500	157	500	172
Pennsylvania	6,000	114	6,000	115
South Dakota	8,600	579	8,600	572
Texas	1,089	3,947	1,200	4,227
Washington	219	364	92	389
Wisconsin	6,800	182	6,500	179
23 States	132,535	24,170	131,929	24,861

Table 4

Cash Receipts from Cattle & Calf Sales in 10 Leading States and the U.S. in 1959, 1970 & 1975

	1959	1970	1975
	- - - - -(million dollars)- - - - -		
Texas	603	1,382	2,167
Iowa	971	1,431	1,568
Nebraska	567	1,070	1,503
Kansas	456	990	1,102
California	459	845	1,101
Colorado	294	793	1,096
Oklahoma	248	639	874
South Dakota	304	483	830
Missouri	333	515	652
Minnesota	379	492	579
U.S.	7,834	13,633	17,482

Table 5

Beef Cows by Region, Selected Years 1950-76*

Region	1950	1960	1970	1976
	- - - - - -	- thousands	- - - - -	- - - -
Northeast	75	210	258	486
Corn Belt and Lake States	2,070	3,970	5,822	7,886
Southeast	2,816	5,993	9,167	11,457
Northern Plains	3,121	4,592	6,410	6,954
Southwest	5,081	6,564	8,995	10,109
Mountain	2,473	3,326	4,683	4,736
Pacific	1,107	1,689	2,004	2,023
48 States	16,743	26,344	37,339	43,651

Percent of Total

Region	1950	1960	1970	1976
Northeast	0.5	0.8	0.7	1.1
Corn Belt and Lake States	12.4	15.1	15.6	18.0
Southeast	16.8	22.8	24.5	26.2
Northern Plains	18.6	17.4	17.2	16.0
Southwest	30.3	24.9	24.1	23.2
Mountain	14.8	12.6	12.5	10.9
Pacific	6.6	6.4	5.4	4.6

* Crop Reporting Board, SRS, USDA.

Table 6

Total Cattle on Hand for Selected Years, in Selected States

State	Year	Number (Millions)
Kentucky	1959	1.947
	1964	2.340
	1969	2.591
	1974	3.215
	1977	3.300
Missouri	1959	3.833
	1964	4.522
	1969	4.815
	1974	6.330
	1977	6.400
Oklahoma	1959	3.239
	1964	4.119
	1969	4.812
	1974	6.020
	1977	5.650
Tennessee	1959	1.724
	1964	2.136
	1969	2.243
	1974	2.690
	1977	-----
Mississippi	1959	2.005
	1964	2.350
	1969	1.940
	1974	2.610
	1977	2.670
Georgia	1959	1.353
	1964	1.746
	1969	1.724
	1974	2.103
	1977	2.300
Florida	1959	1.500
	1964	1.822
	1969	1.047
	1974	2.490
	1977	2.800

Table 6

State	Year	Number (Millions)
	1959	8.517
	1964	9.766
Texas	1969	12.484
	1974	16.250
	1977	15.800
	1959	1.526
	1964	1.827
Alabama	1969	1.781
	1974	2.240
	1977	2.360
	1959	1.655
	1964	1.866
Louisiana	1969	1.417
	1974	1.745
	1977	1.760
	1959	4.324
	1964	5.149
Kansas	1969	5.753
	1974	6.990
	1977	6.400
	1959	1.281
	1964	1.573
Arkansas	1969	1.542
	1974	2.140
	1977	2.500

Source: 1970-1977 U.S.D.A. Cattle Inventory

1951-1969 U.S. Census of Agriculture

TABLE 7

INFECTED HERDS QUARANTINED BECAUSE OF BRUCELLOSIS AS OF December 31, 1977

	TOTAL HERD POPULATION	NUMBER OF INFECTED HERDS	INFECTED HERD RATE/1000
Alaska	140	0	0.00
Connecticut	2,300	0	0.00
Hawaii	930	0	0.00
Maine	3,900	0	0.00
Maryland	8,400	0	0.00
New Hampshire	1,700	0	0.00
North Dakota	25,100	0	0.00
Rhode Island	300	0	0.00
South Carolina	22,000	0	0.00
Virgin Islands	29	0	0.00
Minnesota	64,420	2	0.03
Wisconsin	79,900	3	0.04
Oregon	20,667	1	0.05
North Carolina	57,000	4	0.07
Ohio	53,800	4	0.07
Michigan	37,300	4	0.11
Indiana	47,000	9	0.19
Pennsylvania	46,000	13	0.28
Illinois	51,500	15	0.29
Wyoming	6,900	2	0.29
Virginia	45,000	14	0.31
Arizona	33,989	11	0.32
West Virginia	21,000	8	0.38
New Jersey	2,400	1	0.42
South Dakota	25,800	13	0.50
Nebraska	40,926	21	0.51
Utah	9,400	5	0.53
Iowa	61,000	35	0.57
Washington	21,819	17	0.78
Massachusetts	2,400	2	0.83
Montana	18,848	16	0.85
New York	40,000	34	0.85
Colorado	20,463	18	0.88
Delaware	1,000	1	1.00
California	26,844	28	1.04
x Missouri	110,000	139	1.26
x Kansas	51,700	75	1.45
New Mexico	8,456	14	1.66
Nevada	2,153	6	2.79
x Kentucky	90,000	332	3.69
Vermont	5,300	20	3.77
x Georgia	49,000	210	4.29
x Tennessee	88,000	410	4.66
Idaho	18,437	127	6.89
x Arkansas	52,000	371	7.13
x Alabama	54,000	416	7.70
x Oklahoma	72,645	693	9.54
Puerto Rico	13,400	129	9.63
x Mississippi	62,000	727	11.73
x Texas	162,900	2,363	14.51
x Louisiana	37,000	578	15.62
x Florida	18,000	700	38.89
TOTAL	1,795,166	7,591	4.23

* As of November 30, 1977. December data not available for Puerto Rico

Table 8

Number of livestock slaughtering establishments, by type of inspection, by Census Regions March 1, 1975 and percentage change 1968-75.

Region and State	Under Federal Inspection		Other		Total	
	1975	Percentage change 1968-75	1975	Percentage change 1968-75	1975	Percenta change 1968-75
	Number	Percent	Number	Percent	Number	Percent
Northeastern States	417	441.6	307	-77.7	724	-50.1
Northeast	20	66.7	99	-45.0	119	-38.0
Middle Atlantic	397	510.7	208	-82.6	605	-52.0
North Central States	520	127.1	2,255	-41.7	2,775	-32.3
East North Central	136	43.2	1,001	-44.0	1,137	-39.6
West North Central	384	186.6	1,254	-39.7	1,638	-25.9
The South	276	97.1	1,745	-37.4	2,021	-31.0
South Atlantic	77	92.5	548	-37.5	625	-25.0
East South Central	85	157.6	360	-32.8	445	-21.8
West South Central	114	70.1	837	-42.7	951	-37.8
The West	272	117.6	295	-51.6	567	-22.9
Mountain	103	139.5	221	-45.4	324	-27.7
Pacific	169	106.1	74	-63.9	243	-15.3
United States	1,485	160.1	4,602	-46.8	6.087	-33.9

Source: Livestock Slaughter, Statistical Reporting Service, U. S. Department of Agriculture, selected issues.

Table 9

Meat packing plants, by number of employees and value of shipments, United States, 1967 and 1972

Item	1967		1972	
	Plants	Value of shipment	Plants	Value of shipment
	Number	Mil. Dols.	Number	Mil. Dols.
U. S. total	2,697	15,576.3	2,475	23,024.0
Distribution of number of employees:	----------Percent----------			
1-4	43.4	.7	43.0	.7
5-19	21.2	2.6	22.1	2.3
20-49	15.6	7.9	14.3	6.4
50-99	8.2	11.1	8.7	10.5
100-249	6.3	18.2	6.2	18.5
250-499	3.1	21.8	3.4	24.6
500-999	1.1	11.8	1.3	13.2
1,000-2,499	.8	14.4	.8	16.6
2,500 or mcre	.3	11.5	.2	7.2
Total	100.0	100.0	100.0	100.0

Source: U. S. Dept. of Commerce, Census of Manufacturers.

TABLE 10

ANNUAL REPORT JULY 1975 to JULY 1976

CATTLE SHIPPED INTO WISCONSIN

	BREEDING			FEEDING	* TOTAL
	CATTLE	CALVES	TOTAL	(On permit only)	
Arizona	79	22	101		101
Arkansas	3		3		3
California	70	5	75		75
Canada	77	1	78		78
Colorado	144	2	146		146
Connecticut	2		2		2
Delaware		1	1		1
Europe					
England	17		17		17
Ireland	4		4		4
Norway	54		54		54
Florida	3		3		3
Georgia	2		2		2
Idaho				2	2
Illinois	2,289	73	2,362	356	2,718
Indiana	99	111	210		210
Iowa	740	39	779	83	862
Japan	3		3		3
Kansas	41	1	42		42
Kentucky	187	5	192		192
Maryland	5		5		5
Massachusetts	1	1	2		2
Michigan	295	97	392	8	400
Minnesota	3,566	156	3,722	232	3,954
Mississippi	142		142	91	233
Missouri	70	1	71		71
Montana	64	6	70	592	662
Nebraska	159	8	167	419	586
New Hampshire	10		10		10
New Jersey	2	2	4		4
New York	26	4	30		30
North Carolina	3		3		3
North Dakota	18	4	22	599	621
Ohio	324	35	359		359
Oklahoma	13	1	14	172	186
Oregon	2	1	3		3
Pennsylvania	148	13	161		161
South Dakota	357	37	394	363	757
Tennessee	162		162	98	260
Texas	5		5	100	105
Utah	3		3		3
Vermont	5		5		5
Virginia	19		19		19
Washington	3		3		3
West Virginia	3		3		3
Wyoming	13		13		13
Total	9,232	626	9,858	3,115	12,973

*Excludes steers, spayed heifers and calves under 6 months of age.

Table 11

National Total Tested 1967-77

MCI		MRT	
1967	4,612,964	1973	8,460,030
1968	4,779,652	1974	8,989,563
1969	4,932,167	1975	11,242,879
1970	4,900,526	1976	14,628,284
1971	5,400,969	1977	13,501,362
1972	7,266,150		

FIGURE 1

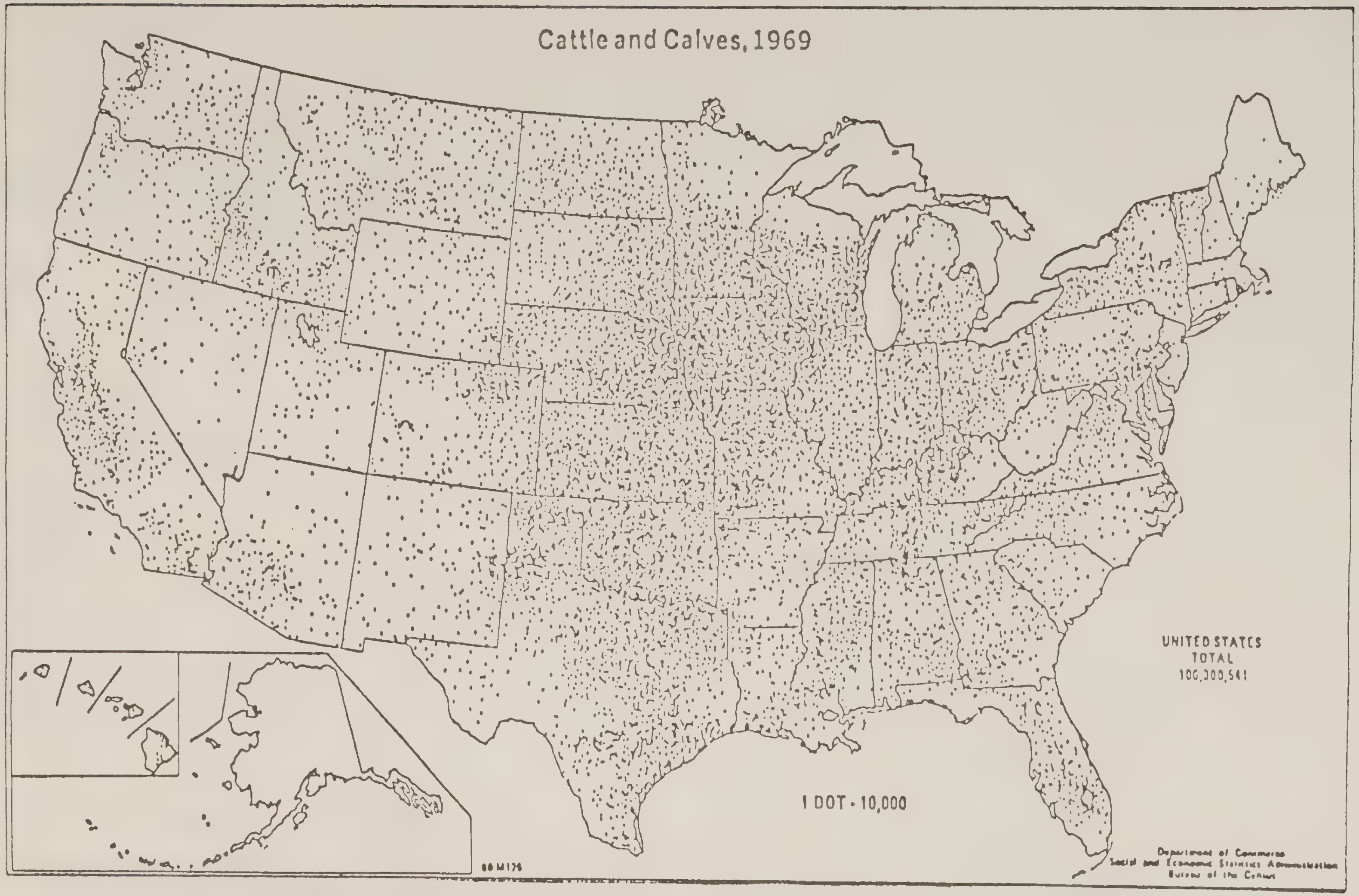
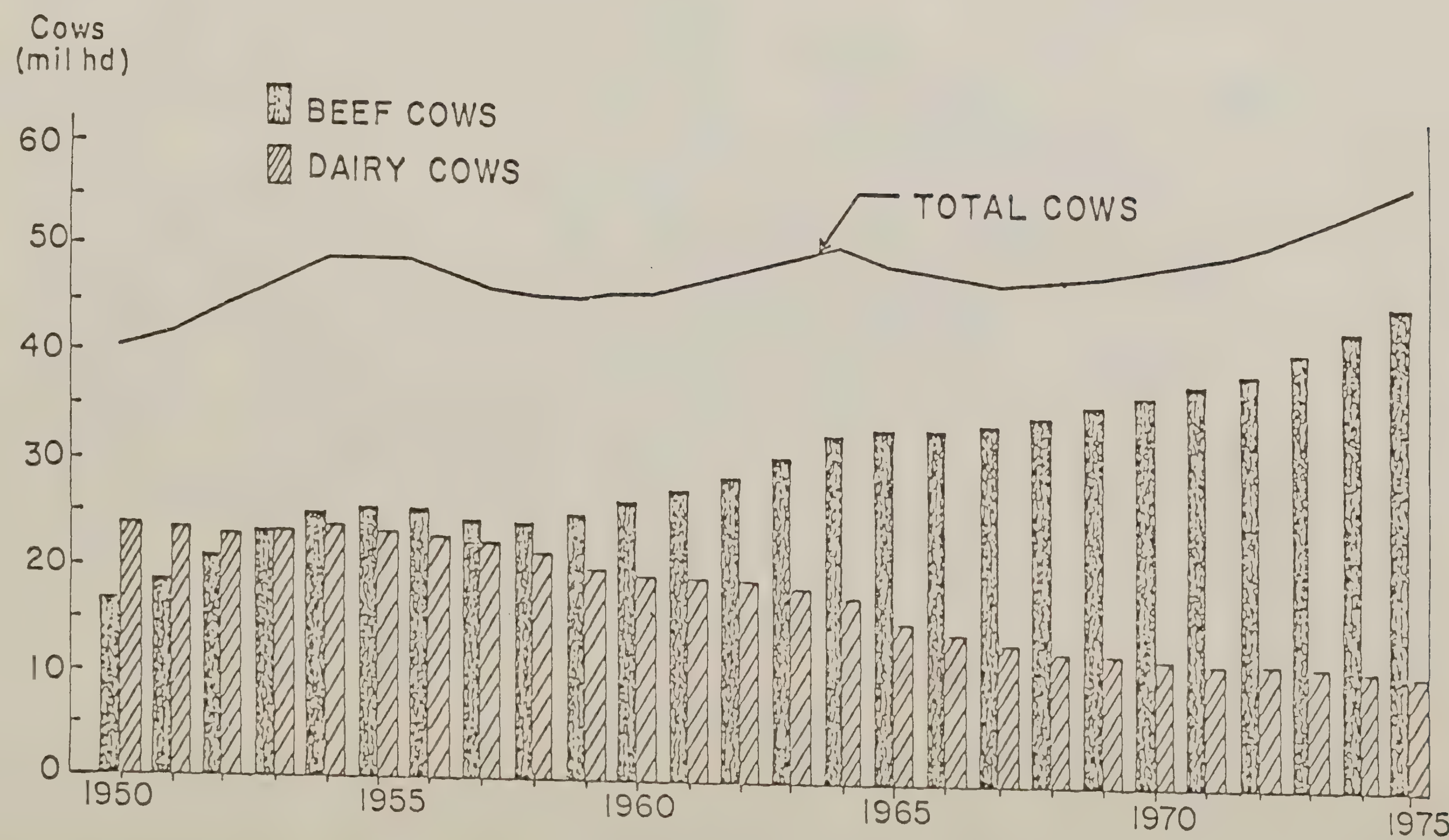

Cattle and Calves, 1969
UNITED STATES
TOTAL
106,300,541
1 DOT - 10,000
Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census

FIGURE 2

Beef and Dairy Cows on Farms, January 1, United States, 1950-75



Source: Livestock and Meat Statistics, U. S. Dept. of Agriculture

FIGURE 3

QUARANTINED HERDS BECAUSE OF BRUCELLOSIS AS OF:

$$\frac{\text{December 31, 1977 - 7,591}}{\text{December 31, 1976 - 8,437}}$$

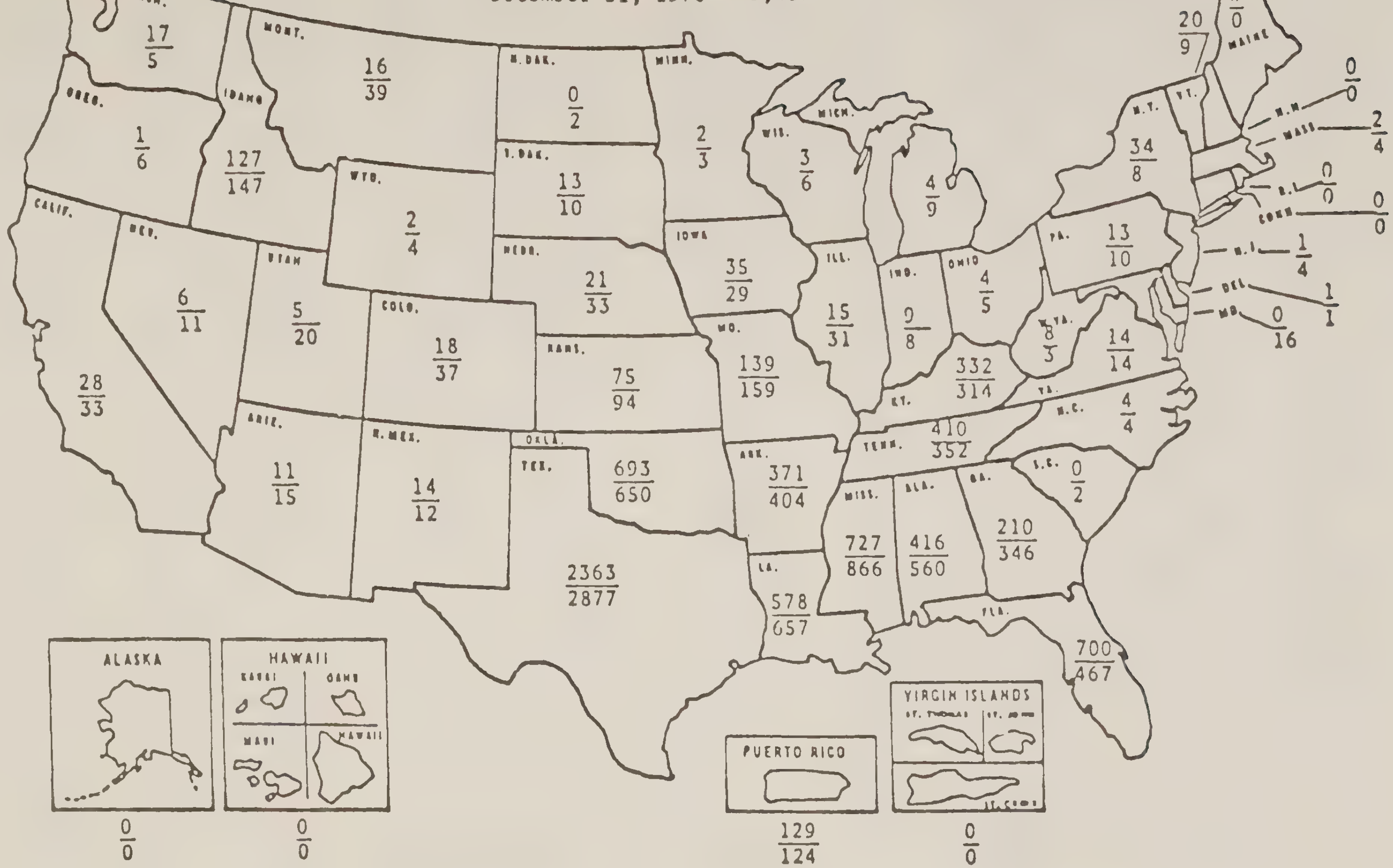


Fig. 4

Light Calves Leave Feedlot, Shortfed Heifers Stay on Feed

WINTERS -- When the cattle market changes as abruptly as it has in recent weeks, a lot of feedlot plans get changed too. Here at Win-Tex Cattle Feeders some cattle which had been slated to stay a long time went out instead, and some which were scheduled to go out stayed in.

Raymond Walston, manager since last fall in the 9000 head feedlot, says the rapid escalation in prices for light calves caused feedlot customers to alter their intentions on some which had come in earlier and had gone on a growing ration. The original plan was to keep them all the way through to slaughter finish.

They got to be worth so much as stockers that most of them have been resold to go back to grass in other, wetter parts of the country.

On the other hand, a set of shortfed heifers intended for slaughter was bought last Friday by a major packer and put back on feed. They were projected to stay another 60-90 days to provide more pounds of beef at a time when the packer evidently foresees their being needed even more than today.

Walston says feedlot customers brought in about 2500 calves early in the winter, many in December, intending to carry them all the way to slaughter finish. Weights ranged 250-400 pounds. Most of these have been resold except a pen of about 180 heifers that got too fleshy to go back to pasture. About 300 steers are still in the lot but will be going out April 15 to Kansas or elsewhere for summer grass. These steers weighed 245 pounds coming in and are expected to average about 450 going out.

One set of 615 thin heifers that came in at 250 pounds went out in 47 days weighing 355 pounds, cost of gain 24-1/2 cents a pound. They had averaged costing $28-30 cwt. coming in, and they went out at $45.

The present market situation indicates that they would probably have made a profit either way they went. Their owners decided to take the bird in the hand.

Even their having come in for a long stay on a growing ration represented considerable change. That would have been impractical a year or two ago, when grain prices were higher.

Walston says the light calves have been efficient converters, gaining about a pound of weight to five pounds of a 75 percent grain ration.

These cattle left the state, most to Oklahoma grazeout wheat.

At the other extreme, the feedlot last week sold 122 heifers that weighed 721 pounds after being on feed 122 days. They were in acceptable slaughter finish and were expected to go that route. But the packing firm which bought them at $45 left them in the same pen and announced plans to let them stay another 60-90 days, depending upon the need for them. They are expected to go to slaughter at 900-925 pounds.

Walston says the change in plans for light calves has been going on to some degree for several weeks, but only in recent days has he been hearing much about heifers being bought and left on feed.

Cost of gain on this set of heifers has run about 37 cents a pound up to now but can be expected to be higher during the extended feeding period as weights escalate.

The feedlot is standing at about two-thirds of capacity lately, reflecting customer resistance to high prices on feeder replacements.

Source: Livestock Weekly, March 30, 1978, Page 8.

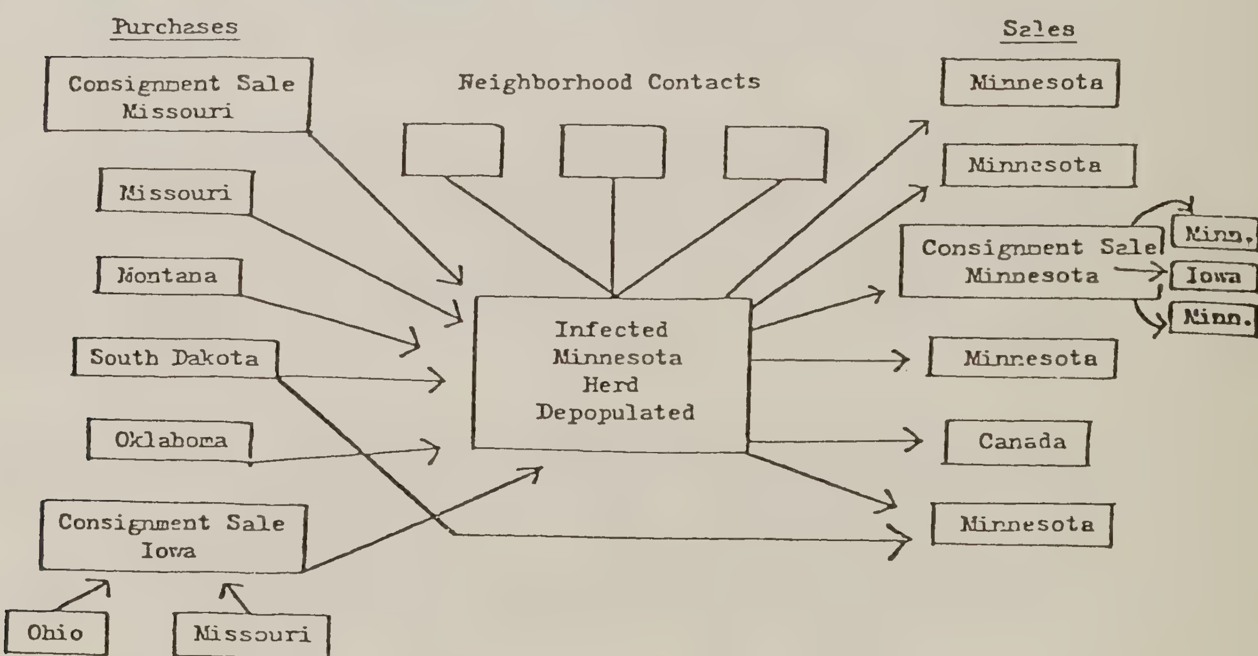
FIGURE 5

STATE OF MINNESOTA
LIVESTOCK SANITARY BOARD
333 WABASHA ST.
ST. PAUL 55102

NEWSLETTER
JULY 1977
VOL. 22 NO. 7

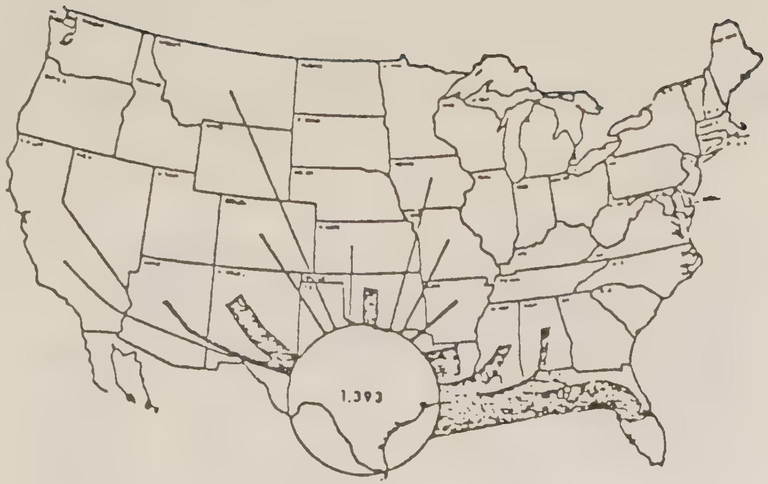
PSEUDORABIES: Report clinical cases: The Board requests that veterinarians report all clinical cases of pseudorabies diagnosed. The true incidence and importance of the disease in Minnesota can not be determined unless all diagnosed cases, clinical or laboratory, are reported to our office. Laboratory confirmation on reported clinical diagnoses would of course be desirable.

BRUCELLOSIS: Cattle do travel: This diagram shows the origin of herd additions to a recently depopulated brucellosis infected Minnesota herd and the sales made and traced out of the herd. Infection was disclosed in the South Dakota source herd shortly after the purchases there and it was the source of infection of the Minnesota herd.

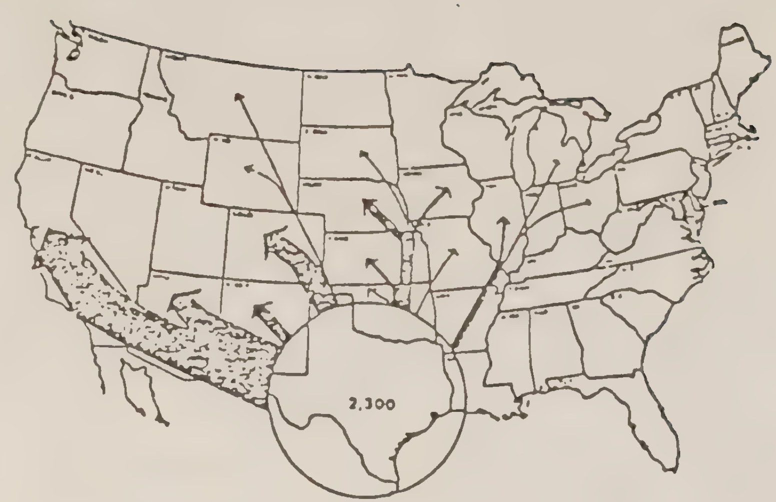


There has been no known spread of the infection from the depopulated herd.

FIGURE 6

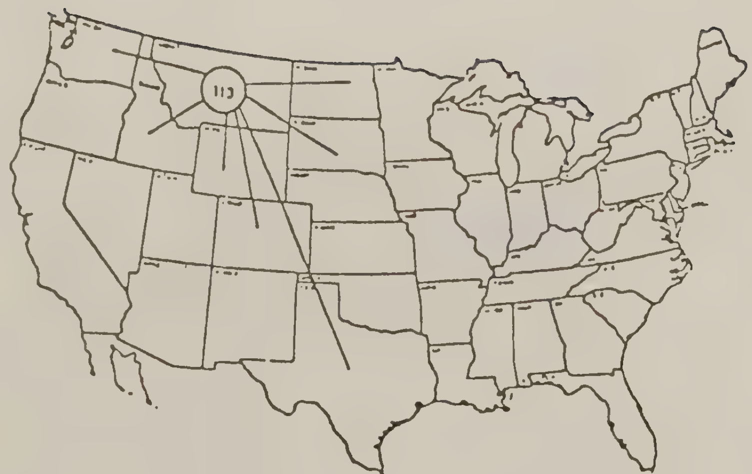


Estimated inshipments of nonfed cattle into Texas, 1962 (1,000).

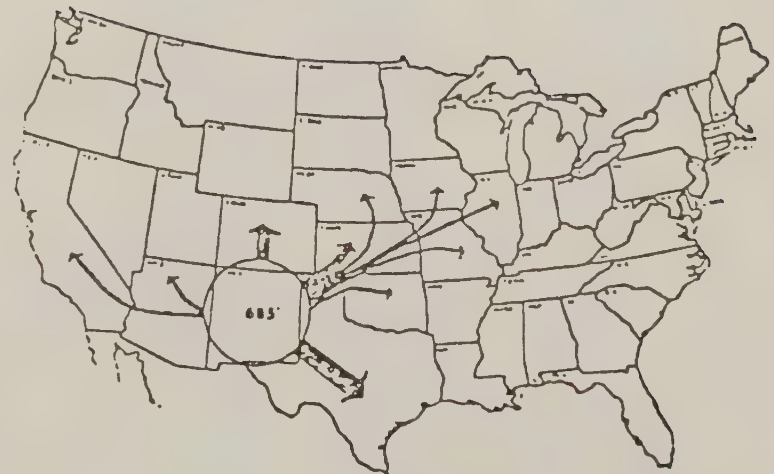


Estimated outshipments of nonfed cattle from Texas, 1962 (1,000).

FIGURE 7



Estimated inshipments of nonfed cattle into Montana, 1962 (1,000).



Estimated outshipments of nonfed cattle from New Mexico, 1962 (1,000).

FIGURE 8

Estimated outshipments of nonfed cattle from Montana, 1962 (1,000).

Estimated inshipments of nonfed cattle into Wyoming, 1962 (1,000).

FIGURE 9

Estimated inshipments of nonfed cattle into New Mexico, 1962 (1,000).

Estimated outshipments of nonfed cattle from Wyoming, 1962 (1,000).

FIGURE 10

Major Directional Movements of Feeder Cattle

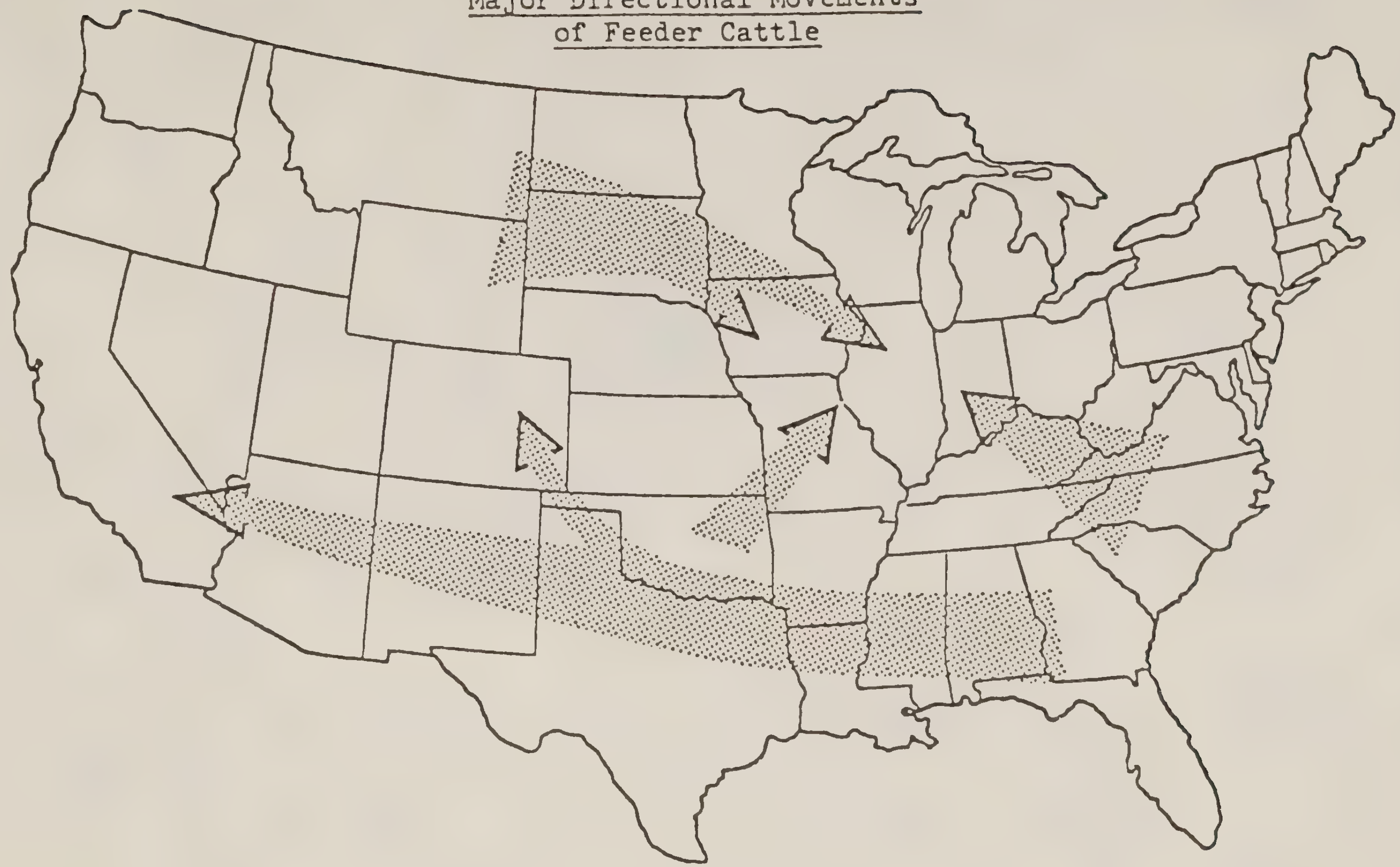


FIGURE 11

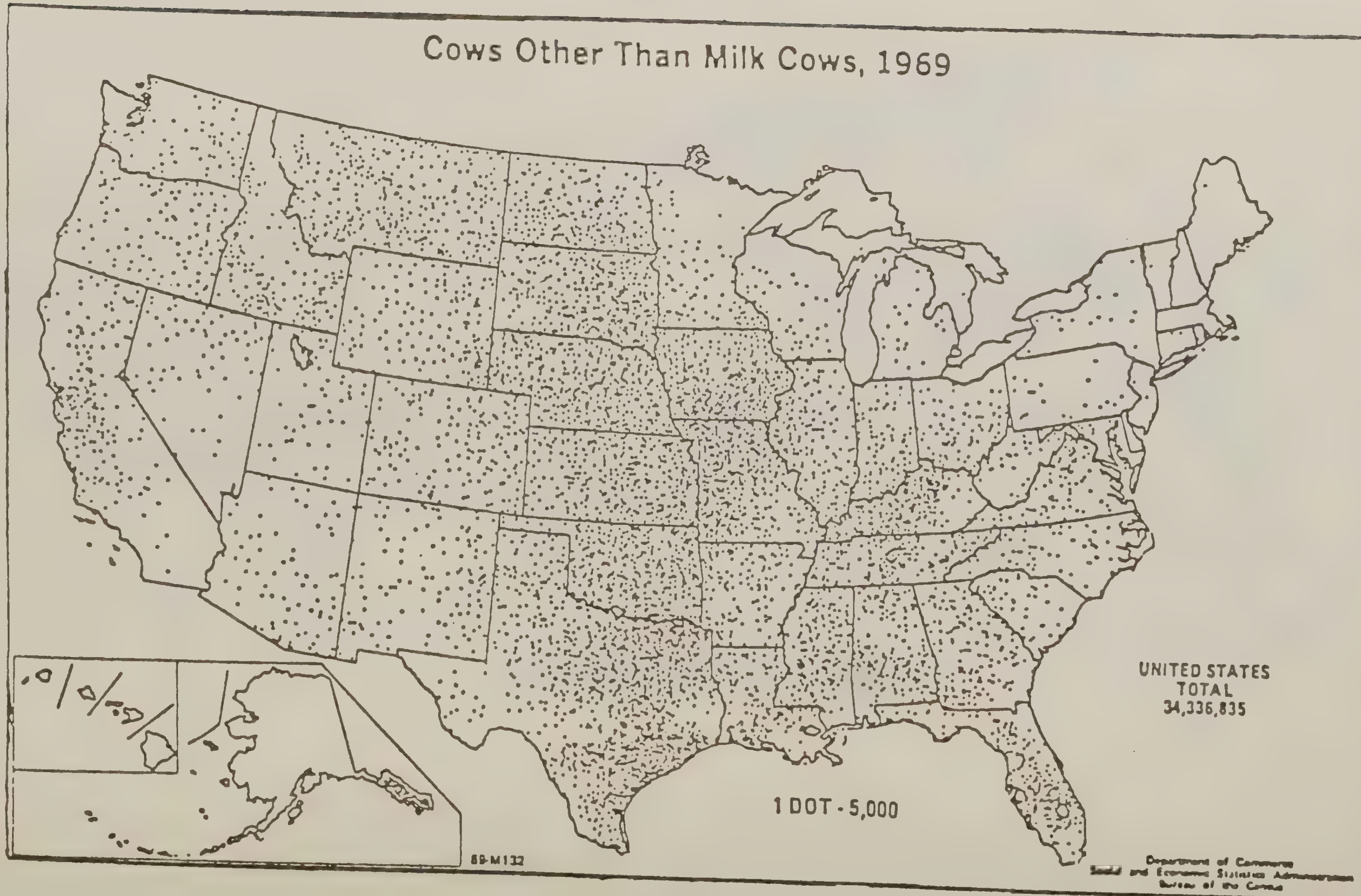

Cows Other Than Milk Cows, 1969
UNITED STATES
TOTAL
34,336,835
1 DOT - 5,000
69-M132
Department of Commerce
Social and Economic Statistics Administration
Bureau of the Census

FIGURE 12

Cattle, Excluding Calves, Fattened On Grain Concentrates and Sold for Slaughter, 1969
(Class 1-5 farms)

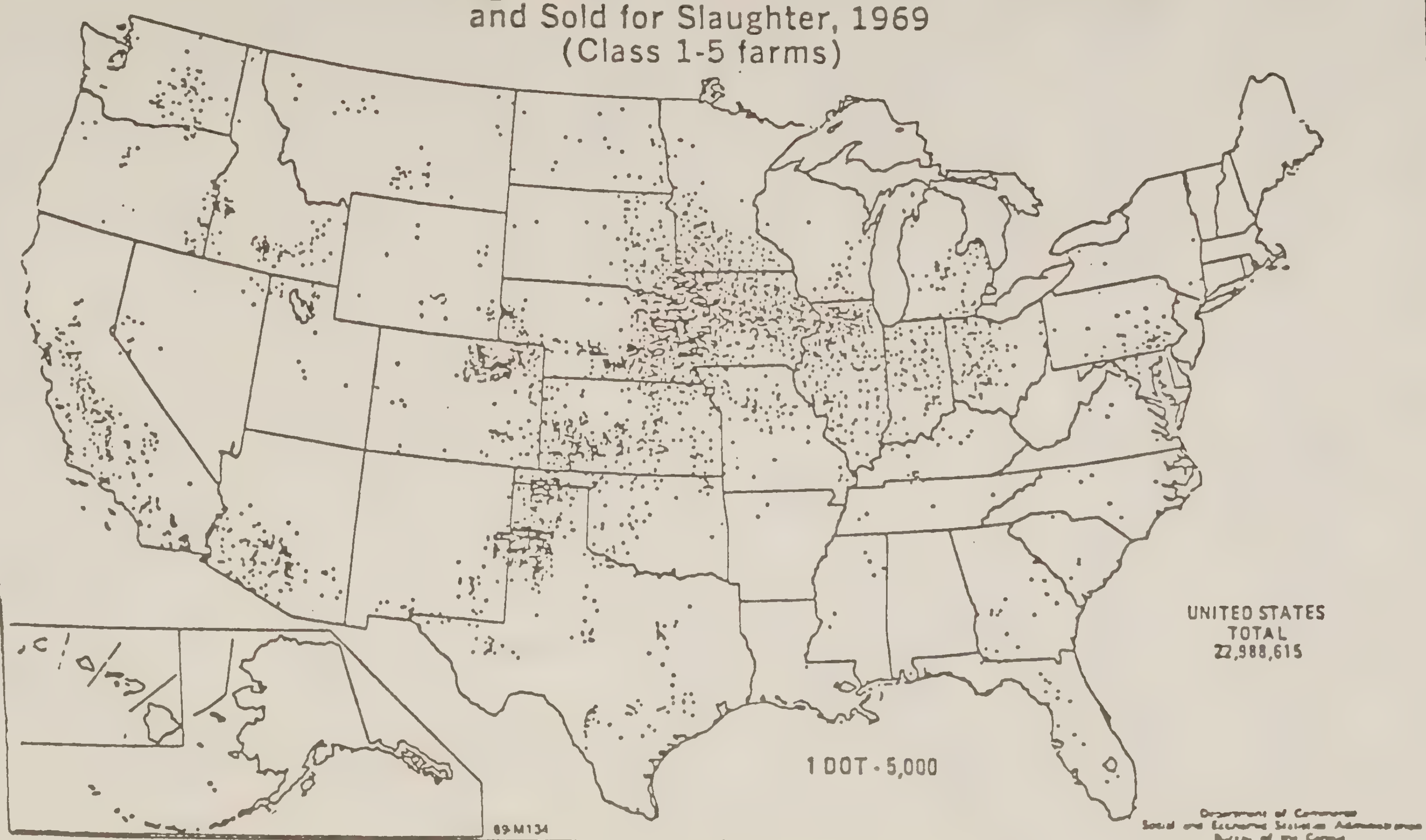
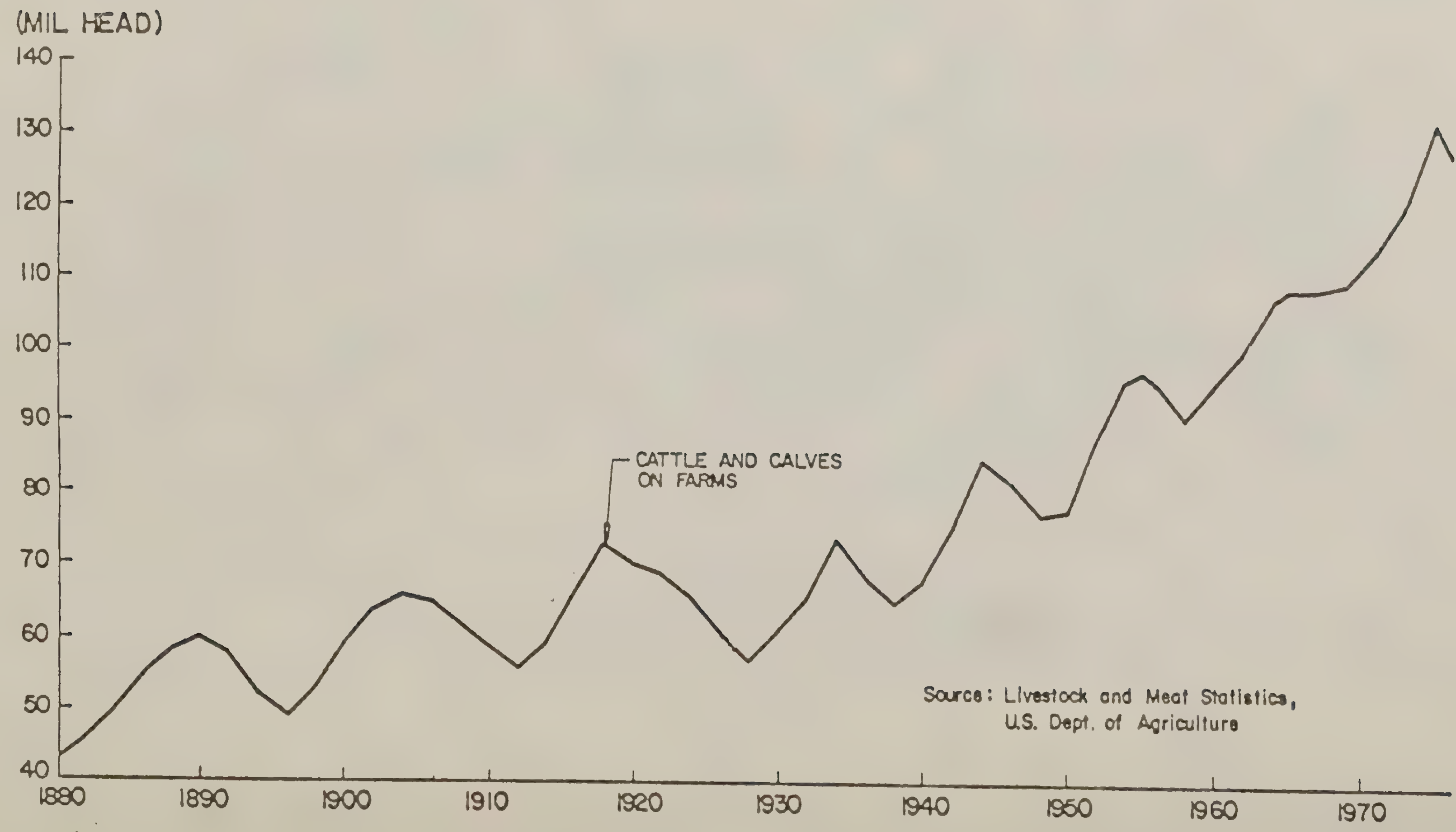


FIGURE 13

CATTLE AND CALVES ON FARMS JAN. 1, 1880-1976



The dairy industry in the U.S.A. has undergone a remarkable set of structural changes over the past 30 years. These changes have been progressing with increasing velocity since the early 1950's, coinciding with the establishment of measures for the brucellosis eradication program.

It is a generally overlooked fact that dairy cows outnumbered beef cows by more than 2 to 1 during the 1930's, that by the early 1950's, the numbers of beef cows equaled those of dairy cows, and that in 1970, the beef cow to dairy cow ratio was more than 2 to 1 (Figs 1,2).

The milk cow population peaked at 27.8 million in 1945, and had decreased to 21 million in 1955. That national decrease has continued unabated so that the average number of milk cows in 1977 was just under 11 million. Strikingly, although there were decreases in total milk production during some of the years between 1955 and 1977, total production in both 1955 and 1978 was approximately 122.9 million pounds. Average milk production per cow nationally went from 5842 pounds in 1955 to 11,194 pounds in 1977 (Table 1). Estimated total cash receipts from milk marketed by farmers in 1977 was $11.8 billion (Table 2).

Almost 50 percent of the milk produced in 1976 came from the five states of California, Minnesota, New York, Pennsylvania and Wisconsin. This concentration of production has not changed significantly over the past 2 decades. Production by states or regions as a percentage of total national production has also not varied greatly (Table 3).

The most striking trend has been the decrease in numbers of dairy operations and the increase in average number of cows per operation. Although the 1974 Census of Agriculture, reported 403,754 dairy herds in the U.S., 55.5 percent of these were in the 1-19 herd size group, with a reported average herd size of 4.78 lactating cows. Other sources, such as brucella ring test data from the states, and our own questionnaire, make it clear that most of these small herds are not commercial dairy herds, and that there are probably something of the order of 220,000 commercial dairy operations. Furthermore, about half of the total milk production now comes from approximately 60,000 herds (4).

From 1969 to 1977, the percentage of Grade A milk produced has moved from approximately 69 percent to almost 82 percent (Fig. 3, Table 4). This trend continues at the rate of approximately 2 percent per year. During that period, cream sold to plants has dropped from approximately 42 million pounds of butter fat to 15 million pounds (Table 5). These trends represent the shift to larger operations, bulk tank handling, consumer pressure for particular products, plant pressure for higher standards for manufacturing grade milk, as well as economies of scale in handling. As the capital costs on the farm for meeting Grade A

standards are only slightly more than those for meeting current standards for milk of manufacturing grade, if a change is to be made it will be to meet Grade A standards (2).

Approximately 80 percent of the Grade A production is subject to minimum price regulation at the producer level through the Federal milk marketing orders (Fig. 4), and most of the remaining Grade A milk is also subject to minimum price regulation by various State milk marketing orders. Grade B production does not come under such regulation. It relies on the price support program for a floor price but is otherwise priced in the open market. In 1977, the number of producers delivering milk to handlers regulated under federal orders was 122,462.

Grade A milk used for fluid consumption is classified as Class I milk. Class II milk is Grade A milk used in the production of "soft" dairy products such as ice cream, cottage cheese, yogurt and sour cream. The remaining Grade A milk, Class III, is used in manufactured products along with Grade B. Class III and Grade B milk, therefore, compete in the same end use market. This procedure of classifying milk according to use, and pricing each class of milk differently is referred to as the classified pricing system.

The mechanism by which the minimum Class I price is currently set in the Federal orders is a fixed differential above the competitive pay price for milk used in manufacturing. The competitive pay price used is known as the Minnesota-Wisconsin (M-W) price series. The M-W price is determined monthly via a USDA sampling of the prices paid for milk by dairy product manufacturers in Minnesota and Wisconsin. The M-W is considered to be the best indicator of overall industry supply-demand conditions and thus represents a competitive price.

The Class I price at the base pricing point, Eau Claire, Wisconsin, in a fixed differential above the M-W price two months previous. The level of Class I price in the U.S. follows approximately concentric circles from this base pricing point, determined by the cost of transporting 100 pounds of fluid milk in 100 mile increments. Thus, as one moves further away from Eau Claire the minimum Class I price increases in relation to transportation costs.

Prices for milk used in classes other than Class I also are generally based on prices paid at dairy manufacturing plants in Minnesota and Wisconsin for milk used in manufacturing. The average, or "blend price", received by Minnesota and Wisconsin farmers for manufacturing milk, in addition to being the basis for all Class I prices, is also the most common basis for pricing Class II and Class III milk.

By definition, in the U.S. Public Health Service Model Milk Ordinance, and the Standards of the Interstate Milk Shippers Conference, all milk for pasteurization (i.e. Grade A) shall be from herds under a brucellosis eradication program which meets certain standards, (Appendix

J). For the purposes of this discussion, the most important of these standards are that.... "All brucellosis tests, retests, disposal of reactors, vaccination of calves, and certification of herds and areas shall be in accordance with the recommended Uniform Methods and Rules for brucellosis eradication....All reactors disclosed on blood agglutination tests shall be separated immediately from the milking herd; the milk of these reactors shall not be used for human consumption."

These health requirements for access to the Grade A milk market have constituted the strongest single incentive for producers to participate in the brucellosis eradication program. They were first imposed by the Chicago Board of Health in 1951, to take effect in 1955 and were adopted by essentially all other milk markets over the next decade.

The trend to larger production units and fewer handlers and processors has made herd surveillance for infection by the brucellosis milk ring test (BRT) simpler to administer, although it has also produced some technical complications.

While the objectives of the Federal marketing orders are to stabilize market conditions, and producers' income, the accelerating trend to increased production of Grade A milk in the brucellosis-free Upper Midwest and Northeast also has some important policy implications with respect to the brucellosis programs. For example, in 1977 approximately 67 percent of Wisconsin's total milk production, or approximately 13.6 billion pounds, met Grade A fluid milk standards. Of that amount, only 23.8 percent, or approximately 3.24 billion pounds was actually marketed as Class I milk and the remaining 10.3 billion pounds was marketed as manufactured milk. This 10.3 billion pounds approximated the total fluid Grade A milk marketed in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, and Tennessee.

During 1977, federal purchases of dried skim milk powder, American cheese and butter amounted to $750 million, and represented a milk equivalent of 6.092 billion pounds (Table 5). In that year for example, the blend price received by producers in the South Eastern Florida market was $11.59 per cwt while that received in the Chicago regional market was $9.08, a differential of $2.51 per cwt (Table 6). Significantly, 91 percent of the producers' deliveries in South Eastern Florida were used in Class I milk, and only 30 percent of those in the Chicago Regional market were used in Class I (Table 7). While a major amount of the price support subsidy for federal purchases were made in the milk surplus areas of the Upper Midwest and North East, that subsidy system directly supports, to the same proportionate extent, the blend price paid to producers in the other marketing areas.

Program records indicate that the prevalence of brucellosis in commercial dairy herds has stabilized over the last few years at approximately 600 herds, and that most of these infected herds are concentrated in the Southeastern and South Central states. In contrast, in

the "Certified Free" states brucellosis in dairy herds represents re-introduction which has been traced to replacement heifers or cows from outside the area (5,8). Within the past 5 years, such reintroductions have occurred in California, Pennsylvania, New York, Vermont, Massachusetts, Michigan, and generally, but not always, have been contained without secondary spread. There has been no compromise with the requirement that the disease be eradicated in these herds, and depopulation has been used where necessary.

In Florida and the South Central states (Model regions 3,4,5) several trends have contributed to the perpetuation of infection in dairy herds. The national tendency to decreasing herd numbers and increased herd size has been accentuated in those regions. Our survey of 369 commercial dairy herds in our study regions 3,4,5 showed that 97 percent of the herds in Florida (region 4) had more than 100 cows, and in regions 3 and 5 the herd size was above 50 cows for 73 percent and 85 percent of the respondents, respectively.

In general, the larger the herd, the greater the tendency is to purchase replacements. This tendency is most strikingly observed in the very large dairys in Florida (6), and California (8), but occurs everywhere. These replacements are usually obtained as pregnant or recently fresh heifers. On the large establishments, the animals are closely confined and fed in dry lots, and calving is usually in dry cow pens, greatly increasing exposure potential (8).

The dairy cow replacement business has become complex, particularly that part of the business which supplies large commercial herds in the Southeast and South Central states. Specialized enterprises operated by part time operators or retired dairy farmers have developed, in which heifer calves are raised to about 6 months of age. The calves may then be sold to another individual who has pasture or silage, or both, and raises them in larger groups to 15 to 18 months of age. At this time they will be bred, either on the same premises, or by another operator. The bred heifers are frequently moved, through a network of dealers, southward until they are placed in a dairy herd. During the first two years of their lives these animals may pass through 3 to 4 sets of hands, in as many as 3 states. Thus, a calf with a Wisconsin ear tag might be raised on pasture from 6 to 15 months of age in contact with infected beef cattle in Kentucky, be bred on another infected premises in Georgia, and placed by a dealer on a South Florida dairy as a "close up" heifer. Her potential exposure would be vastly different from that of an animal which was shipped as a "close up" heifer directly from Wisconsin (Fig. 5). Examination of health certificates for Wisconsin heifer calves shows that no more than half of them were vaccinated prior to outshipment (3). Heifers calves originating in states such as New York or Pennsylvania would be even less likely to have been vaccinated.

Recent investigations in epidemic theory lead to the conclusion that vaccine-induced "herd immunity" requires immunization of essentially all of the individuals in unstable populations such as the one just discussed (7). These theoretical calculations are borne out for bovine brucellosis in the observations of large dairy herds in California (8). Furthermore, data from California (8) and Florida (7) make it clear that a combination of vaccination, removal of identifed infected animals, and sanitary methods to minimize transmission are necessary to free these herds of infection.

There is not unanimity of opinion, among regulatory officials, as to the optimal strategy in use of Strain 19. In California, which imports many of its replacements, vaccination is mandatory for dairy calves, whether home raised or imported. In contrast, in New York and Puerto Rico, since about 1969, vaccination has been seen as increasing program costs, including costs of unnecessary quarantine of herds because of residual Strain 19 titers. As long as virulent infection was not reintroduced, this was a reasonable strategy. The recent introductions both in the Northeast and in Puerto Rico, with secondary spread, demonstrate how susceptible such unvaccinated populations are.

When infection in these large herds is revealed by routine surveillance and the reactors disclosed on initial test are removed, several sets of consequences usually follow. In order to maintain production, and the cash flow it generates, replacements are added to the herd, and the debt burden in the enterprise is increased. A 30 day retest schedule must be begun, and adhered to, with removal of reactors, if the herd is to retain its access to the Grade A market. As indicated above, combined strategies are often required to free large herds from infection. Where primary reliance has been placed on trying to "test a head" of infection it has often resulted in a "revolving door" situation with removal of reactors and their immediate replacement at high cost. In particular cases this has resulted in dairies refusing to participate in the program, retaining reactors, refusing to test, and appealing from court orders obtained by regulatory officials. It is interesting that the sanctions of the Grade A milk ordinance have not been brought to bear in some states in this situation.

Since 1952, the prevalence of brucellosis has been brought from an estimated level of 35 percent of the herds in the nation to approximately 0.27% of the 220,000 commercial herds. National prevalence has apparently stabilized at about that level, and the program which results in that stabilized prevalence, with most infected herds in the South, produces continuing high costs to the federal government and all of the state governments, for surveillance, vaccination, herd testing, and indemnity payments, as well as the high losses sustained by those herd owners directly affected. These federal government brucellosis program costs which are associated with a relatively small number of herds, may be considered to be compounded by the production subsidy which is afforded equally to infected and non-infected herds. It is clear to the

Commission that the benefit of ending these long term costs dictates the implementation of additional measures which would result in complete eradication from the dairy cattle population.

The problem is complicated by the fact that the dairy and beef cattle populations are not entirely independent of each other. Opportunity exists for transmission of brucellosis between neighboring herds, for example, in adjoining pastures. Exposure in common marketing channels can also occur. This leads to the conclusion that the factors which dictate the adoption of a program of eradication of the disease from the dairy cattle population also call for a program of control leading to eradication in the beef cattle population.

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TABLE 1

Milk production and factors affecting supply, United States, selected years, 1955-78

Year	Milk cattle on farms, January 1			Milk cows on farms, average during year	Milk production		Average prices received by farmers per 100 pounds		
	Milk cows and heifers that have calved	Milk cow replacements; heifers 500 pounds and over			Per cow	Total	All milk, wholesale	Milk, eligible for fluid market	Milk, manufacturing grade
		Total	Per 100 cows						
	Thou.	Thou.	No.	Thou.	Lb.	Mil. lb.	Dol.	Dol.	Dol.
1955	21,320	6,832	32.0	21,044	5,842	122,945	4.01	4.50	3.15
1960	17,650	5,686	32.2	17,515	7,029	123,109	4.21	4.69	3.25
1965	15,380	4,780	31.1	14,953	8,305	124,180	4.23	4.63	3.34
1966	14,490	4,450	30.7	14,071	8,522	119,912	4.81	5.17	3.97
1967	13,725	4,215	30.7	13,415	8,851	118,732	5.02	5.43	4.06
1968	13,115	4,080	31.1	12,832	9,135	117,225	5.24	5.67	4.22
1969	12,550	3,990	31.8	12,307	9,434	116,108	5.49	5.87	4.45
1970	12,091	3,880	32.1	12,000	9,751	117,007	5.71	6.05	4.70
1971	11,909	3,843	32.3	11,839	10,015	118,566	5.87	6.19	4.86
1972	11,776	3,828	32.5	11,700	10,259	120,025	6.07	6.38	5.08
1973	11,622	3,872	33.3	11,413	10,119	115,491	7.14	7.42	6.20
1974	11,297	3,941	34.9	11,230	10,293	115,586	8.33	8.66	7.13
1975	11,220	4,087	36.4	11,143	10,350	115,334	8.75	9.02	7.63
1976	11,087	3,958	35.7	11,055	10,879	120,269	9.66	9.93	8.56
1977	11,035	3,888	35.2	10,984	11,194	122,957	9.72	9.96	8.70
1978	10,930	3,896	35.6						

Source: Dairy Situation No. 369, March, 1978: Table 4, p.9.

TABLE 2

Cash receipts from farm marketings of milk and cream, United States, by production regions, 1972-1977 1/

State and region	1972	1973	1974	1975	1976	1977 2/
				Million dollars		
Maine	46.7	50.8	59.3	61.1	66.9	67.9
New Hampshire	24.9	27.3	30.8	32.0	35.6	36.1
Vermont	138.9	151.8	176.2	185.1	213.6	213.2
Massachusetts	47.4	50.6	58.0	59.9	65.9	66.5
Rhode Island	4.9	5.2	6.0	5.9	6.4	6.1
Connecticut	48.0	52.0	60.9	60.7	66.7	66.7
New York	647.2	704.0	811.9	859.6	987.4	983.5
New Jersey	44.0	45.7	49.4	48.8	56.6	56.7
Pennsylvania	473.0	525.7	620.5	662.2	779.6	808.8
Delaware	9.1	9.9	11.4	11.8	13.8	14.0
Maryland	104.9	113.9	133.6	140.7	157.3	162.2
NORTHEAST	1,589.0	1,736.9	2,018.0	2,127.8	2,449.8	2,481.7
Michigan	299.5	325.4	353.9	376.3	447.8	452.6
Wisconsin	1,035.1	1,201.3	1,394.4	1,500.5	1,810.4	1,890.4
Minnesota	479.2	570.5	666.7	675.3	785.1	817.0
LAKE STATES	1,813.8	2,097.2	2,415.0	2,552.1	3,043.3	3,159.8
Ohio	282.5	309.0	335.8	372.0	436.8	437.5
Indiana	146.7	163.1	186.5	188.1	217.3	222.8
Illinois	162.1	179.1	197.1	199.1	228.5	230.9
Iowa	224.9	262.2	290.2	304.2	365.0	372.5
Missouri	165.1	195.6	227.4	227.2	266.6	271.3
CORN BELT	981.3	1,109.0	1,237.0	1,290.6	1,494.2	1,535.0
North Dakota	43.2	57.3	62.7	62.9	75.5	76.1
South Dakota	78.7	97.4	111.9	111.9	138.2	141.9
Nebraska	82.3	95.6	106.7	109.3	123.4	117.8
Kansas	95.5	102.3	111.1	119.3	133.0	136.4
NORTHERN PLAINS	299.7	352.6	392.4	403.4	470.1	472.2
Virginia	112.9	125.7	151.9	162.3	187.3	192.9
West Virginia	21.2	23.7	28.3	29.8	33.8	31.3
North Carolina	103.8	118.9	139.1	149.4	161.9	174.4
Kentucky	138.7	149.2	178.8	184.3	212.9	221.6
Tennessee	127.2	141.2	162.6	168.8	193.8	187.9
APPALACHIAN	503.8	558.7	660.7	694.6	789.7	808.1
South Carolina	37.1	42.1	52.0	52.8	57.3	59.0
Georgia	86.8	96.0	116.5	115.4	135.2	133.7
Florida	149.5	172.1	211.4	222.8	240.2	239.2
Alabama	57.3	64.3	68.8	69.6	72.2	72.6
SOUTHEAST	330.7	374.5	448.7	460.6	504.9	504.5
Mississippi	63.9	70.9	79.9	80.6	86.2	85.7
Arkansas	43.6	49.2	58.6	58.7	68.3	71.1
Louisiana	79.0	85.9	102.8	106.4	117.3	114.5
DELTA STATES	186.5	206.0	241.3	245.7	271.8	271.3
Oklahoma	73.9	85.0	100.4	93.4	106.8	109.5
Texas	235.4	263.7	305.8	299.3	346.9	357.4
SOUTHERN PLAINS	309.3	348.7	406.2	392.7	453.3	466.9
Montana	17.8	19.1	22.6	22.2	23.7	26.9
Idaho	82.9	100.1	112.5	123.2	137.2	140.7
Wyoming	7.8	8.6	9.6	8.9	10.4	11.3
Colorado	59.2	65.5	76.1	75.4	85.6	86.7
New Mexico	26.0	27.7	33.5	37.1	44.4	47.0
Arizona	44.9	60.6	73.7	78.0	89.9	94.2
Utah	51.4	60.3	75.0	77.9	87.8	87.6
Nevada	8.5	9.8	14.0	14.5	17.7	18.9
MOUNTAIN	298.5	351.7	417.0	437.2	496.7	513.3
Washington	144.8	170.5	195.4	208.3	240.1	253.3
Oregon	63.0	72.6	84.8	88.6	101.0	103.6
California	608.1	693.0	896.3	997.2	1,089.1	1,180.8
PACIFIC	815.9	936.1	1,176.5	1,294.1	1,430.2	1,537.7
Alaska	2.0	2.1	2.6	2.7	2.7	2.8
Hawaii	14.5	16.5	19.4	20.5	21.9	23.2
UNITED STATES	7,145.3	8,090.0	9,453.6	9,922.5	11,428.6	11,776.5

1/ Totals may not add due to rounding.
2/ Preliminary.

Source: Dairy Situation No. 370, May, 1978: Table 4, p. 12.

Table 3

MILK PRODUCTION BY REGIONS, STATES FOR SELECTED YEARS 1969-1976

State and Region	1969	1971	1973	1975	1976[1]	% of U.S. Total 1973	% of U.S. Total 1976
			Million Pounds				
Maine	618	629	614	629	633	0.5	0.5
New Hampshire	359	359	337	336	335	.3	.3
Vermont	1,920	2,025	1,948	2,009	2,125	1.7	1.8
Massachusetts	681	658	595	601	598	.5	.5
Rhode Island	80	70	64	63	60	.1	---
Connecticut	679	660	614	608	616	.5	.5
New York	10,351	10,431	9,728	9,964	10,244	8.4	8.5
New Jersey	782	684	575	528	545	.5	.5
Pennsylvania	6,998	7,155	6,718	7,140	7,507	5.8	6.2
Delaware	138	133	128	127	130	.1	.1
Maryland	1,563	1,564	1,464	1,510	1,540	1.3	1.3
NORTHEAST	24,169	24,368	22,785	23,515	24,333	19.7	20.2
Michigan	4,592	4,796	4,636	4,411	',620	4.1	3.8
Wisconsin	18,051	18,848	18,442	18,900	20,296	16.0	16.9
Minnesota	9,727	9,618	9,271	8,946	9,239	8.1	7.7
LAKE STATES	32,370	33,262	32,349	32,257	34,155	28.1	28.4
Ohio	4,463	4,488	4,267	4,259	4,503	3.7	3.7
Indiana	2,381	2,430	2,329	2,210	2,272	2.0	1.9
Illinois	2,999	2,795	2,717	2,560	2,499	2.4	2.1
Iowa	4,885	4,577	4,180	3,893	4,120	3.5	3.4
Missouri	3,077	2,999	2,992	2,840	2,972	2.6	2.5
CORN BELT	17,805	17,289	16,485	15,762	16,366	14.3	13.6
North Dakota	1,103	1,023	1,044	917	911	.9	.8
South Dakota	1,567	1,557	1,569	1,472	1,551	1.4	1.3
Nebraska	1,612	1,569	1,542	1,431	1,409	1.3	1.2
Kansas	1,687	1,688	1,505	1,403	1,461	1.3	1.2
NORTHERN PLAINS	5,969	5,837	5,660	5,223	5,332	4.9	4.4
Virginia	1,775	1,751	1,690	1,756	1,834	1.5	1.5
West Virginia	391	363	333	350	336	.3	.3
North Carolina	1,485	1,500	1,524	1,602	1,666	1.3	1.4
Kentucky	2,447	2,480	2,330	2,319	2,383	2.1	2.0
Tennessee	2,104	2,122	1,946	1,875	1,946	1.7	1.6
APPALACHIAN	2,202	2,216	7,823	3,902	8,165	6.8	6.8

Table 3

State and Region	1969	1971	1973	1975	1976[1]	% of U.S. Total 1973	% of U.S. Total 1976
			Million Pounds				
South Carolina	506	516	497	512	523	.4	.4
Georgia	1,124	1,188	1,168	1,199	1,279	1.0	1.1
Florida	1,559	1,785	1,843	1,956	2,057	1.6	1.7
Alabama	808	819	785	686	682	.7	.6
SOUTHEAST	3,997	4,308	4,293	4,353	4,541	3.7	3.8
Mississippi	1,061	1,011	950	876	862	.8	.7
Arkansas	692	698	706	707	736	.6	.6
Louisiana	1,078	1,129	1,062	1,054	1,088	.9	.9
DELTA STATES	2,831	2,838	2,718	2,637	2,686	2.4	2.2
Oklahoma	1,257	1,260	1,140	1,060	1,102	1.0	.9
Texas	2,987	3,239	3,280	3,208	3,309	2.8	2.7
SOUTHERN PLAINS	4,244	4,499	4,420	4,268	4,411	3.8	3.7
Montana	336	334	312	278	281	.3	.2
Idaho	1,420	1,550	1,657	1,555	1,554	1.4	1.3
Wyoming	146	135	130	110	113	.1	.1
Colorado	848	885	854	845	835	.7	.7
New Mexico	308	312	318	366	405	.3	.3
Arizona	573	620	737	840	882	.6	.7
Utah	783	840	866	919	924	.7	.8
Nevada	139	141	144	168	179	.1	.1
MOUNTAIN	4,553	4,817	5,018	5,081	5,173	4.3	4.3
Washington	1,982	2,230	2,338	2,322	2,428	2.0	2.0
Oregon	937	1,008	1,008	990	1,027	.9	.9
California	8,898	9,710	10,332	10,853	11,575	9.0	9.6
PACIFIC	11,817	12,948	13,678	14,165	15,030	11.8	12.5
Alaska	18	17	18	17	16	---	---
Hawaii	133	133	138	146	148	.1	.1
UNITED STATES	116,108	118,532	115,385	115,326	120,356	100.0	100.0

Source: Dairy Situation Numbers 349, 354, 359, 364, 1974-1977, Table 3 "Milk: Production by Production Regions, With Comparisons."

[1]Preliminary

Table 4

Percent of Fluid Grade Milk Sold to Plants and Dealers, by States, For 1970-74

Year / State	1970	1971	1972	1973	1974
MAINE	100	100	100	100	100
NEW HAMPSHIRE	100	100	100	100	100
VERMONT	100	100	100	100	100
MASSACHUSETTS	100	100	100	100	100
RHODE ISLAND	100	100	100	100	100
CONNECTICUT	100	100	100	100	100
NEW YORK	100	100	100	100	100
NEW JERSEY	100	100	100	100	100
PENNSYLVANIA	98	98	98	98	98
DELAWARE	100	100	100	100	100
MARYLAND	100	100	100	100	100
MICHIGAN	88	88	90	91	94
WISCONSIN	54	56	58	59	61
MINNESOTA	29	33	36	36	41
OHIO	89	90	91	92	92
INDIANA	84	85	86	87	84
ILLINOIS	74	78	76	77	78
IOWA	33	36	35	42	41
MISSOURI	62	63	65	65	65
NORTH DAKOTA	35	35	34	34	34
SOUTH DAKOTA	19	21	24	25	26
NEBRASKA	43	46	48	49	49
KANSAS	76	80	84	84	84
VIRGINIA	85	86	87	89	90
WEST VIRGINIA			NOT AVAILABLE		
NORTH CAROLINA	97	97	98	98	98
KENTUCKY	64	68	71	72	73
TENNESSEE	68	72	76	80	82
SOUTH CAROLINA	NA	100	100	100	100
GEORGIA	100	100	100	100	100
FLORIDA	100	100	100	100	100
ALABAMA	97	97	98	98	98
MISSISSIPPI	90	92	93	94	96
ARKANSAS	64	66	68	71	72
LOUISIANA	100	100	100	100	100
OKLAHOMA	90	89	86	88	89
TEXAS	100	100	100	100	100

TABLE 4

Year State	1970	1971	1972	1973	1974
MONTANA	90	88	90	92	94
IDAHO	27	28	29	32	31
WYOMING			NOT AVAILABLE		
COLORADO			NOT AVAILABLE		
NEW MEXICO	100	100	100	100	100
ARIZONA	100	100	100	100	100
UTAH	71	71	72	72	73
NEVADA	100	100	100	100	100
WASHINGTON	100	100	100	100	100
OREGON	79	81	81	82	83
CALIFORNIA	90	89	89	91	93
ALASKA	100	100	100	100	100
HAWAII	100	100	100	100	100

Source: Milk: Final Estimates for 1970-74, SB 597, February, 1978.

Table 5

Quantity of Milkfat in 1,000 lb. Units, Sold to Plants and Dealers, by Production Regions, 1970 & 1974

Production Region	Year 1970	1974
Northeast	746	554
Lake States	4352	2303
Cornbelt	9206	2903
Northern Plains	22661	7945
Appalachian	395	234
Southeast	00	00
Delta States	00	00
Southern Plains	819	258
Mountain	3014	683
Pacific	1100	407
Alaska	00	00
Hawaii	00	00

Source: Milk: Federal Estimates for 1970-1974, SB 597 February 1978, pp. 12-13

Table 6

Federal Order Minimum Class 1 and Blend Prices for Milk of 3.5 Percent Butterfat Content, F.O.B. Market or Other Indicated Point, January - December, Averages

Marketing Area	Class 1 1977	Class 1 1976	Class 1 Change 1977 Over 1976	Blend 1977	Blend 1976	Blend Change 1977 Over 1976
	Dollars Per 100 Pounds					
New England						
New England	11.46	11.58	0.12-	10.39	10.44	0.05-
Average	11.46	11.58	.12-	10.39	10.44	.05-
Middle Atlantic						
New York-New Jersey	11.12	11.24	.12-	9.85	9.91	.06-
Middle Atlantic	11.26	11.38	.12-	10.10	10.23	.13-
Average	11.18	11.30	.12-	9.94	10.02	.08-
South Atlantic						
Tampa Bay	11.42	11.55	.13-	11.31	11.39	.08-
Southeastern Florida	11.63	11.75	.12-	11.59	11.63	.04-
Upper Florida	11.32	11.44	.12-	11.36	11.34	.02-
Georgia	10.78	10.90	.12-	10.31	10.40	.09-
Average	11.19	11.31	.12-	10.94	11.01	.07-
East North Central						
Eastern Group						
Southern Michigan	10.08	10.20	.12-	9.43	9.50	.07-
Eastern Ohio-Western Pa.	10.33	10.45	.12-	9.59	9.65	.06-
Ohio Valley	10.19	10.30	.11-	9.60	9.65	.05-
Average	10.20	10.31	.11-	9.53	9.59	.06-
Western Group						
Michigan Upper Peninsula	9.83	9.95	.12-	9.27	9.27	0
Chicago Regional	9.74	9.86	.12-	9.08	9.06	.02
Lsville-Lxgton-Evnsville	10.18	10.12	.06	9.58	9.52	.06
Indiana	9.93	10.07	.14-	9.48	9.54	.06-
Southern Illinois	10.01	10.13	.12-	9.49	9.55	.06-
Central Illinois	9.87	9.99	.12-	9.43	9.38	.05
Average	9.87	9.97	.10-	9.21	9.21	0
West North Central						
Northern Group						
Upper Midwest	9.60	9.70	.10-	8.86	8.87	.01-
Eastern South Dakota	9.88	10.04	.16-	9.25	9.26	.01-
Black Hills	10.45	10.54	.09-	9.58	9.52	.06
Iowa	9.87	9.95	.08-	9.25	9.31	.06-
Nebraska-Western Iowa	10.08	10.20	.12-	9.30	9.33	.03-
Average	10.06	10.19	.13-	9.30	9.32	.02-
West North Central						
Southern Group						
St. Louis-Ozarks	10.08	10.20	0.12-	9.53	9.58	0.05-
Greater Kansas City	10.22	10.35	.13-	9.45	9.51	.06-
Neosho Valley	10.15	10.26	.11-	9.98	10.05	.07-
Wichita	10.28	10.40	.12-	9.57	9.58	.01-
Average	10.14	10.26	.12-	9.51	9.56	.05-

Table 6

Marketing Area	Class 1 1977	Class 1 1976	Class 1 Change 1977 Over 1976	Blend 1977	Blend 1976	Blend Change 1977 Over 1976
	Dollars Per 100 Pounds					
East South Central						
Paducah	10.17	10.35	.13-	9.86	10.00	.14-
Nashville	10.33	10.20	.13	9.56	9.47	.09
Memphis	10.41	10.55	.14-	10.11	10.24	.13-
Tennessee Valley	10.58	10.67	.09-	10.10	10.15	.05-
Average	10.34	10.34	0	9.76	9.76	0
West South Central						
Northern Group						
Central Arkansas	10.42	10.54	.12-	10.10	10.26	.16-
Oklahoma Metropolitan	10.46	10.58	.12-	9.83	9.83	0
Red River Valley	10.66	10.81	.15-	10.07	10.17	.10-
Texas Panhandle	10.73	10.85	.12-	10.12	10.39	.27-
Lubbock-Plainview	10.90	11.02	.12-	10.55	10.61	.06-
Average	10.51	10.64	.13-	9.97	10.04	.07-
Southern Group						
Greater Louisiana	10.94	11.01	.07-	10.57	10.57	0
New Orleans-Mississippi	11.32	11.40	.08-	10.62	10.59	.03
Texas	10.80	10.92	.12-	10.23	10.27	.04-
Average	10.80	10.92	.12-	10.23	10.27	.04-
Mountain						
Eastern Colorado	10.78	10.90	.12-	10.22	10.26	.04-
Great Basin	10.39	10.49	.10-	9.60	9.62	.02-
Western Colorado	10.48	10.60	.12-	10.04	10.03	.01
Central Arizona	11.00	11.12	.12-	10.10	10.12	.02-
Rio Grande Valley	10.83	10.95	.12-	10.33	10.40	.07-
Lake Mead	10.08	10.20	.12-	9.70	9.71	.01-
Average	10.72	10.84	.12-	10.02	10.06	.04-
Pacific						
Puget Sound	10.34	10.44	.10-	9.36	9.32	.04
Inland Empire	10.44	10.55	.11-	9.52	9.59	.07-
Oregon-Washington	10.44	10.55	.11-	9.66	9.67	.01-
Average	10.40	10.50	.10-	9.50	9.49	.01
41-Market Average	10.62	10.74	.12-	9.76	9.80	.04-
All-Market Average	10.59	10.70	.11-	9.69	9.75	.06-

Source: Federal Milk Order Market Statistics No. 216, Table 3, pp.10-11, February, 1978.

Table 7

Producer Milk Deliveries to Handlers Regulated Under
Federal Orders and Deliveries, Percent Used in Class I by Marketing Area,
January - December

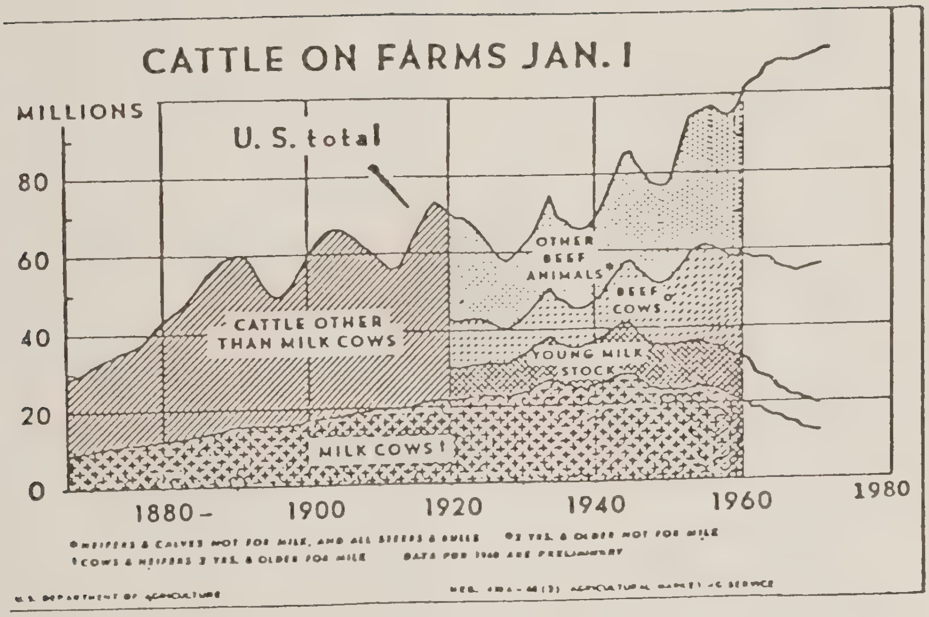
Marketing Area	% Used in Cl. I 1977	1976
	Percent	
New England		
New England	59	60
Total	59	60
Middle Atlantic		
New York-New Jersey	47	49
Middle Atlantic	58	61
Total	51	53
South Atlantic		
Tampa Bay	88	87
Southeastern Florida	91	89
Upper Florida	93	88
Georgia	78	78
Total	85	84
East North Central Eastern Group		
South Michigan	54	58
Eastern Ohio-Western Pa.	60	61
Ohio Valley	62	63
Total	58	60
East North Central Western Group		
Michigan Upper Peninsula	57	56
Chicago Regional	30	32
Lsville-Lxgton-Evnsville	62	62
Indiana	66	65
Southern Illinois	53	54
Central Illinois	63	56
Total	40	42
West North Central Northern Group		
Upper Midwest	22	28
Eastern South Dakota	46	47
Black Hills	52	53
Iowa	44	51
Nebraska - Western Iowa	50	49
Total	50	49
West North Central Southern Group		
St. Louis - Ozarks	67	68
Greater Kansas City	52	52
Neosho Valley	91	89
Wichita	60	59
Total	62	61

Table 7

Marketing Area	% Used in Cl. I 1977	1976
	Percent	
East South Central		
Paducah	78	79
Nashville	56	57
Memphis	84	86
Tennessee Valley	74	76
Total	67	68
West South Central Northern Group		
Central Arkansas - Fort Smith	84	88
Oklahoma Metropolitan	66	64
Red River Valley	71	72
Texas Panhandle	74	82
Lubbock - Plainview	86	85
Total	72	73
West South Central Southern Group		
Greater Louisiana	84	83
New Orleans - Mississippi	72	70
Texas	75	74
Total	75	74
Mountain		
Eastern Colorado	74	72
Great Basin	55	56
Western Colorado	75	72
Central Arizona	62	61
Rio Grande Valley	78	78
Lake Mead	68	64
Total	66	66
Pacific		
Puget Sound	41	41
Inland Empire	50	55
Oregon - Washington	56	58
Total	48	49
42 - Market Total	55	56
All - Market Total	53	55

Source: Federal Milk Order Statistics, No. 216, Table 7, pp. 18-19, February 1978.

FIGURE 1



CATTLE ON FARMS JAN. 1, 1880 TO 1970

Data after 1961 added by author from USDA annual livestock inventory reports.

Source:

Livestock And Meat Marketing

John H. McCoy,Ph.D.

Avi Publishing Co.,

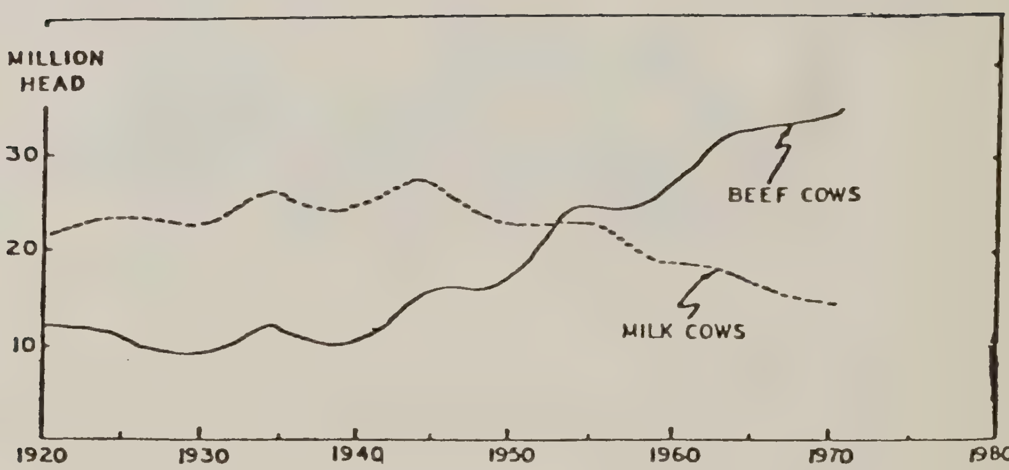
Westport, Connecticut

1972

Chapter 4, "Livestock Production and Supply"

p.51.

FIGURE 2

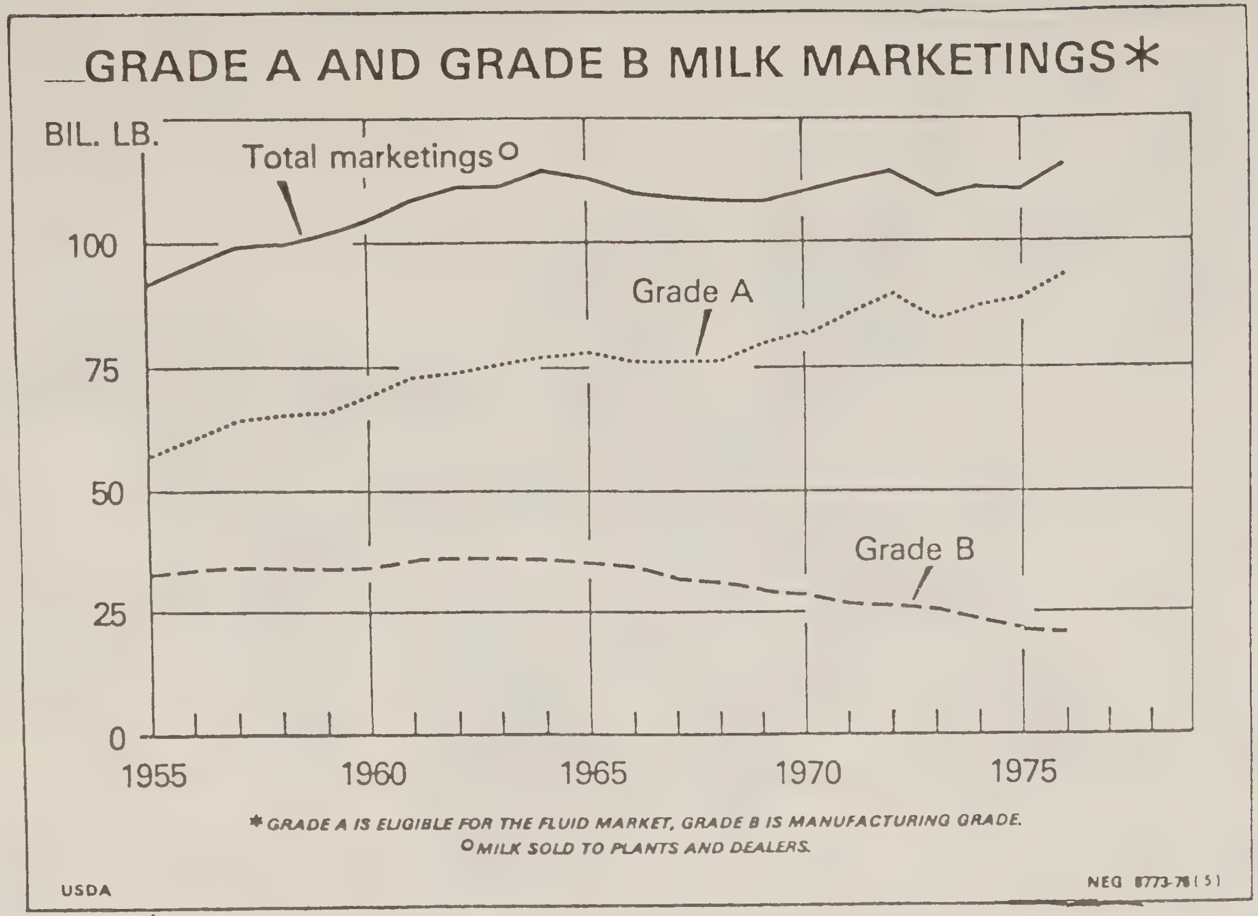


NUMBER OF BEEF COWS AND MILK COWS ON FARMS AND RANCHES, JAN. 1, 1920-1971

Source:

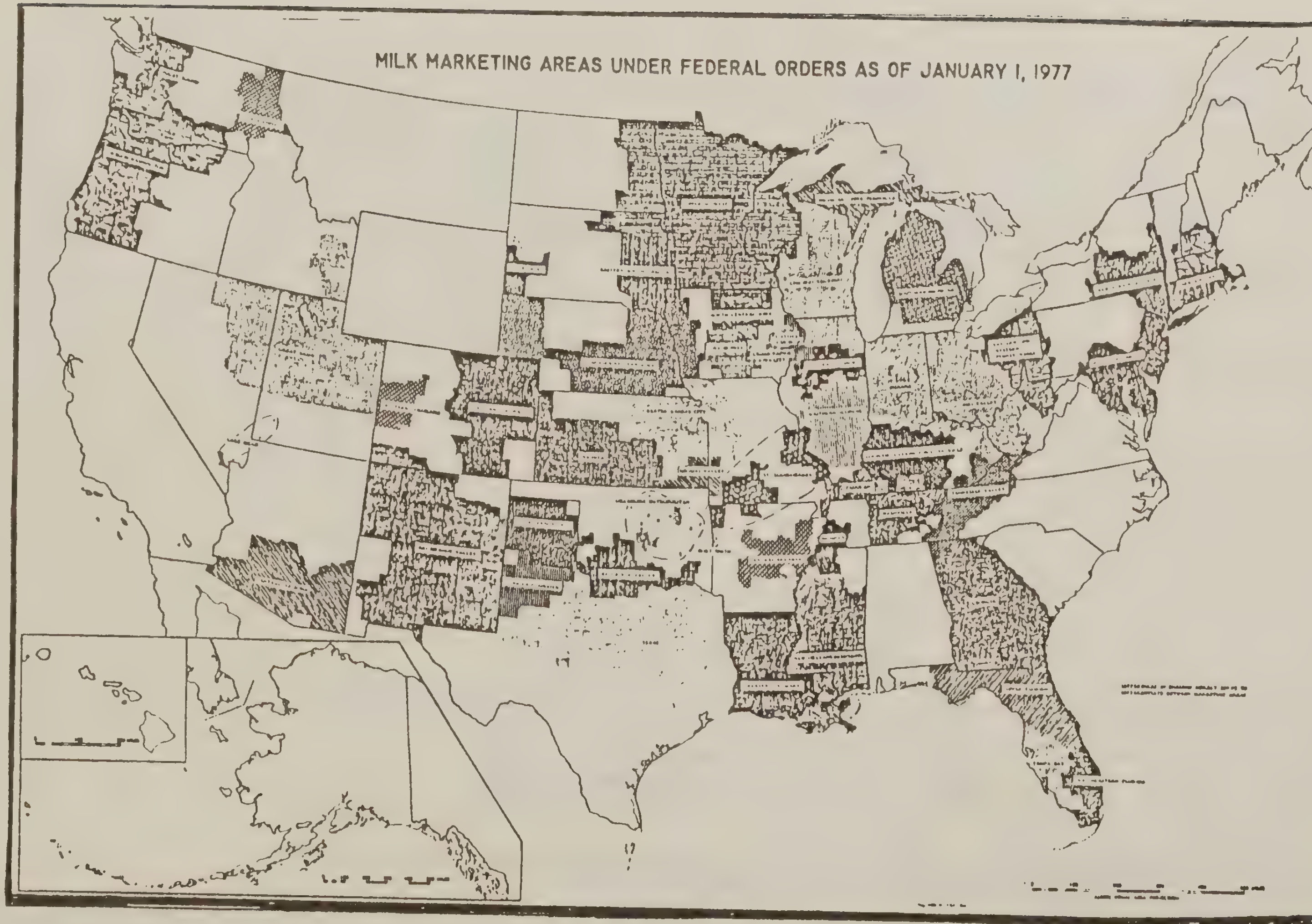
Livestock And Meat Marketing
John H. McCoy, Ph.D.
Avi Publishing Co.
Westport, Connecticut
1972
Chapter 4,"Livestock Production and Supply"
p.52

FIGURE 3



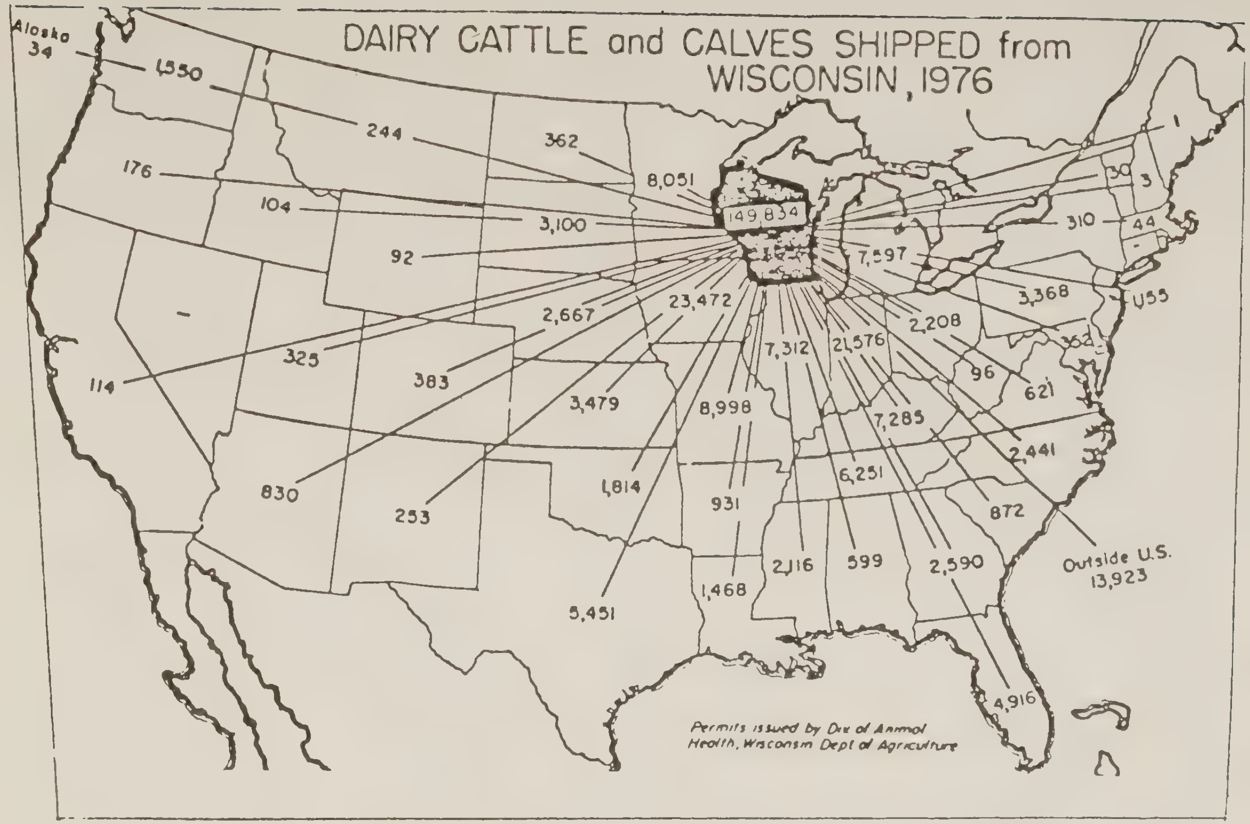
Source: Dairy Situation,No. 365, May, 1977, p. 9.

FIGURE 4



Source: Federal Milk Order Market Statistics, No. 216, February, 1978, p. 37.

FIGURE 5



Source: 1977 Wisconsin Agricultural Statistics,
Wisconsin Stasistical Reporting Service, p. 79.

Section 4.4

Biologic Factors Influencing Control Leading to Local Eradiction of Brucellois

Within the concept of local eradication, as it has been defined by the Commission, (Section 4.1) and within the charge to the Commission, all presently available data support the conclusion that biologic knowledge, essential to accomplish local eradication of brucellosis, is available. Additionally, data from many individual herds, counties and states in the U.S., and from a number of other countries such as Australia, Germany, and Sweden provide evidence that no biologic constraint was significant enough to prevent accomplishment of local eradication of brucellosis from cattle. The Subcommittee on Brucellosis Research of the National Academy of Sciences stated in their 1977 report, "The Subcommittee feels that current information is adequate to accomplish the goal of eradication of brucellosis from cattle". Also, at the Texas A & M University Symposium on Brucellosis in 1976, experts from at least seven countries agreed that sufficient biologic knowledge is available for prevention, control and local eradication of bovine brucellosis.

Local eradication includes the concepts of maintaining surveillance, to detect reintroduction of brucellosis into the cattle population, measures to prevent such reintroduction, and an emergency plan to quickly stamp-out any such reintroduction if it occurs.

Thus, all available evidence supports the conclusion that present biologic knowledge is adequate to achieve local eradication with continuing surveillance, if one is willing to accept the Commission's definition for local eradication, as generally accepted for foot and mouth disease of cattle, vesicular exanthema of swine, and viscerotropic velogenic Newcastle disease of chickens and turkeys.,

On the other hand, brucellosis is a complex infectious disease and although we have a considerable amount of knowledge, we also lack some important knowledge of brucellosis which requires continuing research. The Brucellosis Technical Commission, and other expert groups cited, recognize that educational, social, political and economic factors also influence the ease, rapidity and cost of surveillance and local eradication.

Sources of Data

Data for evaluation of the biologic factors were obtained from among hundreds of articles reporting research results, articles reviewing published data, reports of conferences, and reports of advisory committees. Two reports which provided an excellent current data base for this section are:

1. Brucellosis Research: An Evaluation by the Subcommittee on Brucellosis Research, National Academy of Sciences (1977).

2. Bovine Brucellosis: An International Symposium, Texas A & M University Press, (1976).

Data and conclusions presented here are based on our own synthesis of available knowledge.

Biologic Factors Related to the Agent (Brucella abortus)

Factors which may influence local eradication in cattle include among others, the following:

Cattle may be infected with other species of Brucella but all present evidence indicates that only B. abortus is a significant species in maintaining and transmitting brucellosis within the cattle population of the United States.

B. abortus may infect species other than cattle, but B. abortus has a strong preference for cattle. All present evidence indicates that horses, chickens, dogs, swine, sheep and various other domestic and wild animals may be infected by B. abortus but these animals do not have a significant role in maintaining and naturally transmitting B. abortus among their own species, or among cattle. Exceptions to this general observation are documented regarding buffalo (bison) and elk; however, these exceptions can be accommodated within the definition of local eradication.

B. abortus infection has been maintained and transmitted among the buffalo kept in Yellowstone National Park. Although it is biologically possible to eliminate the disease from buffalo in Yellowstone Park, it is not politically nor ecologically feasible at this time. These buffalo pose a biologic problem as a source of infection, but transmission may be prevented by management practices to prevent association of Park buffalo with cattle. No evidence of spread from these buffalo to cattle outside the Park has been documented, but this reservoir will require surveillance in this local area, to protect cattle from reintroduction of the infection. The U.S. Fish and Wildlife Service has a position statement on brucellosis in this buffalo population which gives suggestions for prevention of infection of cattle and for improving control of brucellosis in the Yellowstone buffalo herd (Appendix H).

Brucella abortus infection is being maintained and transmitted among elk in several herds in Wyoming, which are artificially (domestically) fed with hay during the winter. This dense population of elk in a limited feeding area provides ideal conditions for transmission of the agent from aborted fetuses to cow elk. The Wyoming State Game and Fish Department, with aid from the U.S. Department of Interior and U.S. Department of Agriculture, is sponsoring research on the disease in several elk herds. This includes research on vaccination. Although it has been demonstrated in research projects, that susceptible cattle

became infected when confined in close contact with infected cow elk, the senior research scientist has told us that there is no documented evidence that this has occurred under natural range conditions.

Infected elk are apparently capable of transmitting infection to cattle only during a limited part of the year. Appropriate management of the elk on winter feeding grounds, and restriction of movement of cattle for grazing on ranges utilized by elk until June 30, will limit the possibility of exposure of cattle in the area. It may be biologically feasible through vaccination, altered management and severe culling to eliminate B. abortus from these elk herds. Until research provides additional data, this problem will require close surveillance in the elk range to detect the first evidence of natural spread from elk to cattle, and to prevent any secondary spread among cattle.

In summary, there is no documented evidence that wildlife form a natural reservoir for B. abortus infection except in the case of elk and bison in certain situations. In addition, there is no documented evidence of transmission of B. abortus under natural conditions from elk to cattle in Lincoln, Sublette or Teton counties of Wyoming, and no evidence of natural transmission of B. abortus from the bison of Yellowstone National Park to cattle in the area. After reviewing the evidence, it appears that other species of Brucella and other hosts of B. abortus do not pose a significant barrier to control toward local eradication of brucellosis in cattle, as defined in this report. However, continuing research is needed to help solve the problems, along with continuing surveillance to detect the first evidence of transmission from wildlife to cattle and prevent secondary spread in other cattle. It is also important to monitor other animals in all regions of the U.S. for any new evidence of another natural reservoir of B. abortus which might effectively transmit the infection to cattle.

The Commission is aware that some feral swine in the U.S., including Hawaii, are infected with B. suis, and that infection has been transmitted to people. There is no well documented evidence of transmission to domestic swine, but there are reports of close contact in certain situations. Also, there is no evidence of transmission from feral swine to cattle. However, with changing conditions and increased shipping and transfer of feral swine for hunting, it appears that further data are needed, along with continuing monitoring, to determine the extent of the problem, and to gain information that may be useful in the local eradication of brucellosis in swine.

Cows infected with B. abortus may excrete the bacteria in their milk, feces, or from the reproductive tract through vaginal discharges, urine, aborted fetuses, or apparently healthy calves and placentas. Under experimental conditions, B. abortus has survived for less than one day in direct sunlight, or in liquid manure at 157°F (69.5°C), up to eight months in liquid waste tanks at 15°C and at temperatures of -40°C for up to 670 days. However, there is no evidence that survival of B.

abortus in the environment has been a major source of infection for cattle. Thus, there is apparently no significant barrier to local eradication from survival of B. abortus in the environment, given application knowledge of the disease in appropriate management practices.

B. abortus organisms undergo mutation and dissociation in nature as well as in the laboratory, and "L" forms have been reported. There are a number of biotypes of B. abortus, but in the U.S., only biotypes 1, 2 and 4 have been isolated from cattle as field strains, and strain 19, as a vaccine strain. On the basis of presently available data, the differences in the biotypes and biologic characteristics of B. abortus found in the U.S. do not appear to pose a barrier to local eradication.

Dose of B. abortus: The number of B. abortus bacteria which enter the body of the host influence (1) the probability of whether infection will occur and be maintained, (2) the length of the incubation period, and (3) the host response to the bacteria. Dose or number of organisms effectively entering the body of the host thus influences the spread of the infection. This dose factor interacts with stage of pregnancy or estrus cycle in non-pregnant animals. The smaller the number of bacteria, the greater the probability that the host will resist and overcome the infection. Smaller doses may also be related to an increasing period for incubation. The numbers available for exposure are directly influenced by management and sanitation, vaccination, density of animal population and other actions subject to management and regulatory decisions. Dose, as a biologic factor, does not appear to pose a significant barrier to local eradication.

Biologic Factors Related to Transmission

In evaluating current knowledge, there appears to be sufficient knowledge of biologic factors related to modes of transmission among cattle to achieve local eradication. However, prevention of transmission of brucellosis is greatly influenced by sanitation, management, movement and marketing practices, which involve economic and people factors.

Direct transmission of B. abortus may be accomplished by direct contact, of the mouth, nose, eyes, other mucous membranes, and abraded or unabraded skin of susceptible animals, with the skin and hair of the newborn calf, or the vulva and vaginal discharges of the infected cow.

Indirect transmission of the bacteria to a portal of entry in the susceptible animal may be accomplished through infected milk, fetuses, placenta, precalving and postcalving discharges from the reproductive tract of the infected cow as well as through soil, water, urine, manure, hay, grass and other things which may have been contaminated by discharges from the reproductive tract of infected cows.

Infected cows may also transmit infection to their living calves

inutero, or through the suckling of colostrum and milk following birth. Usually calves born to, and nursing, infected dams are serologically negative by six months of age and no brucellae can be isolated. However, recent reports indicate that some calves born to infected dams may have latent infection leading to negative serological responses up to the time of abortion or normal calving after which, the heifer becomes serologically positive. This "latent" infection is thought to occur infrequently, but it may be very important in dealing with delayed transmission in otherwise brucellosis free areas. There has been some evidence that "latent" infection can be detected either by means of the so called anamnestic test with 45/20 vaccine, or with a skin test procedure. The research data are inadequate to make recommendations on use of either method at present under conditions in the U.S., but further research is in progress.

Generally, infection transmitted from cow to cow via vaginal discharges is limited to a short period of time prior to, and a longer period following abortion, when B. abortus is being excreted from the reproductive tract. Occasionally, however, infected cattle may excrete B. abortus in vaginal discharges for up to several weeks prior to, and for a period of several days to several months following abortion or calving, depending on the health of the reproductive tract of the infected cow.

Prevention of transmission of brucellosis for practical considerations can be structured into three herd situations. Brucellosis is a herd disease, and once a cow in a herd is infected, the other cows and heifers must be considered to have been exposed to infection.

Prevention of transmission within herds which have infected and/or exposed cattle, involves restrictions and positive actions such as: herd quarantine to prevent movement; identifying and removing infected animals as a source for transmission of infection; sanitation and appropriate management practices at the time of calving or abortion, to reduce exposure potential for non-infected cows; prior vaccination or current vaccination to reduce infection rates, which reduces the sources of B. abortus, which in turn reduces further transmission.

Prevention of transmission to geographically adjacent or neighborhood herds involves restrictions and positive actions such as quarantine of the infected herd and alerting adjacent and neighborhood owners to the presence of the infected herd nearby so they can maintain separation from direct contact with infected or exposed cattle. It involves obtaining a history of any prior exposure to cows in the infected herd and conducting at least one and preferably two tests of the adjacent or neighborhood herds, at 30-90 day intervals. It should involve prior vaccination to reduce susceptibility to infection, and minimizing indirect transmission by preventing exposure of adjacent cattle to contaminated water, soil, placenta or fetuses carried from the infected farm to neighboring farms. At present, adjacent and neighborhood farms

are often not alerted to the infected herd, so they are unaware of the need to prevent transmission, and are not able to protect themselves. It should be the "right" of adjacent and neighborhood owners of cattle to be notified immediately, whenever infection is found in their neighborhood.

Prevention of transmission of brucellosis between herds in different areas or states need involve no restrictions on the buyer or seller if the areas or states are truly brucellosis free, i.e. every herd is free, and this freedom from the disease is maintained by adequate surveillance. Brucellosis free areas are an economic advantage to the cattle owner, because they permit free movement as desired at his convenience.

Prevention of transmission of brucellosis between herds in different areas or states which are not truly brucellosis free, does require restrictions and positive management actions. There is a considerable range of effective management strategies which can be adopted, based upon local and market conditions. Knowledgeable action by herd owners to protect their own herds can include such options as: (1) maintain a closed herd, raise all replacement calves on the premises, and introduce no cattle from outside into the herd; or (2) when purchasing cattle, obtain assurance from the seller that the cattle are from an identified herd of origin, that the purchased cattle are not now infected and have not been exposed to B. abortus, and then keep these cattle separately until serologic tests are conducted at 30-150 days post-purchase; (3) increase the resistance of his cattle by maintaining a vaccinated herd.

In all areas, except truly brucellosis free states, the safeguards for preventing transmission of brucellosis as outlined above, all involve restrictions on movement of infected animals. They require positive management actions of the buyer, in terms of where to buy, the conduct of a serologic test after purchase, and action in conjunction with program officials. However, these safeguards are not compatible with present commonly used marketing practices, where cattle from many sources are brought together without regard to possible infection or exposure, and then sold to many different buyers who introduce the purchased, possibly infected or exposed cattle into new susceptible herds. Since the exposed and infected cows are the sources of infection, sellers and buyers must become responsible and accountable for selling and buying only brucellosis free cattle to prevent transmission effectively, and to reduce infection. Thus, the variable and sometimes lengthy incubation period, the frequent lack of clinical signs of disease, and some common husbandry and marketing practices, all contribute to transmission and serve as barriers to local eradication. These barriers have not prevented local eradication in many areas, and should not prevent local eradication in other areas if individuals are motivated to accept responsibility for maintaining or buying and selling only brucellosis-free cattle.

The exemption from serologic tests of 13-24 month old cattle which have been calfhood vaccinated, is another important barrier to effective prevention of transmission. This exemption allows these vaccinated heifers to move rather freely, without regard to herd of origin or possible exposure to infected cattle. They have the exemption because the present dose of vaccine, and route and age at administration, result in development of serologic titers, not easily distinguishable from field strain infection. These vaccinal titers may persist for some months. Persistence increases with increasing age at vaccination.

Since vaccination does not provide 100% protection, especially in the face of large exposure doses, some of these beef cattle become infected and abort or calve before they are "test-eligible" at 24 months of age. These infected cattle are an important source of infection when they abort or calve, because they were not previously test-eligible, and yet they moved freely in commerce. Although this is recognized, in the import regulations of a number of the states, it is a significant source of dissemination of infection.

This barrier to prevention could be removed, and these exempt cattle could be made test eligible at 15 months of age if current research on using reduced doses of vaccine and alternate routes of administration is successful. Present findings show that vaccination with reduced doses, or by alternate routes, results in lower peak serologic titers, and a much shorter duration of titer. This research needs to be continued and expanded to facilitate removing the test exemption for vaccinated heifers 13-24 months of age. Prevention of transmission would be greatly improved if vaccinated heifers were uniformly test eligible at 16 months of age.

Biologic Factors Related to Host Response

In evaluating current knowledge, there appears to be sufficient knowledge of biologic factors related to the response of cattle to *B. abortus* for continued progress toward local eradication, as already accomplished in many herds, states in the U.S. and in other countries. However, more knowledge of the disease in cattle obtained from research, and its application would aid progress toward local eradication.

Incubation Period

The period of time between exposure of cattle to field strain *B. abortus* , and the time when either an abortion or a significant serologic response occurs, is known as the incubation period. Usually a significant serologic response is the first detectable sign of infection, but occasionally abortion will occur one to three weeks before a significant serologic response. The average incubation period between exposure and significant serologic response is most commonly 3-12 weeks (21-91 days), but this depends on the dose (number of bacteria) at exposure, the artificial or naturally acquired resistance of the exposed

cattle, their age and pregnancy status. Exposure early in pregnancy, or before pregnancy, usually results in a relatively long incubation period. Recent data indicate that calves born to infected cows may occasionally be infected and fail to have a significant serologic reaction until they are themselves mature. The serologic reaction may be delayed until up to two or three weeks following abortion or calving. This type of latent calfhood infection appears to occur with relatively low frequency, but precise information is not yet available.

The lack of clinical signs, except abortion, and some longer incubation periods are among the biologic factors which contribute to the spread of brucellosis. This is because people factors and economics encourage people to move exposed cattle from one place to another, or through sales with no requirement that the herd of origin be a free herd, and no requirements for the individual animals to have at least two tests at two points in time. Movement of cattle without recognizing that animals can be in the incubation period carries with it the risk that they are potentially capable of spreading brucellosis unless they are within truly brucellosis free areas or from brucellosis free herds.

Variable incubation periods also influence the length of time required for effective quarantine of an infected herd. Most herds do not have residual infection if released from quarantine with a second negative test at least 120 days following the removal of the last reactor from the herd. However, some herds do have recurring infection, which may be due to relatively long incubation periods. These unusually long incubation periods cause conflicts between owners of infected herds and state-federal officials. Quarantines restrict movement of cattle. Owners want the quarantine periods to be as short as possible, so they can move cattle. Regulatory officials want quarantines to be long enough to cover the incubation period of all possibly infected cows. Currently, many states release quarantine with a second negative test at least 120 days following removal of the last reactor, but inform the owner they will offer another test at six months after the last negative test as a surveillance test. This has appeared to work well.

Variability of incubation periods poses a problem in determining safe but reasonable quarantine periods, because they curtail economically optimal cattle movement. On the other hand, infection rates were reduced and local eradication was accomplished in some areas from 1959 to 1967 when the U.M.&R. required only one negative test only 30 days after removal of the last reactor; or from 1967 to 1972 when the U.M.&R. required quarantine for only 60 days and one or two negative tests following removal of the last reactor. Even though these requirements were relatively hazardous, they did not prevent control toward local eradication but did result in slower progress toward that goal (see page 4.6-3). The 1977 U.M.&R. requirements provide more protection and less hazard.

Infection and Infection Rates

Infection occurs when B. abortus bacteria are able to invade and multiply in the host. Establishment of infection is dependent on many factors including the dose of bacteria, the age and pregnancy status of the cattle, and the naturally or artificially acquired resistance of the host.

Calves which are not sexually mature are most resistant to infection, followed by heifers which are not yet pregnant, and pregnant animals are most susceptible to infection.

Under experimental conditions, about 25-30% of non-vaccinated animals are resistant to infection when challenged by a dose of B. abortus that will infect about 25-35% of vaccinated heifers or cows.

With exposure to infection under field conditions, because the age of the animals, their stage of pregnancy and dose of B. abortus are all highly variable, vaccination with Strain 19 may provide up to 95% protection for vaccinated cattle. This is particularly true, if all animals in the herd were vaccinated, as demonstrated in Montana and California.

Infection rates, with or without vaccination, are also greatly influenced by deficiencies of appropriate management and sanitation practices to prevent transmission of the bacteria directly or indirectly through the environment, as shown in studies of dairy herds in California, Florida and Wisconsin.

Infection rates are increased when cattle of unknown origin and unknown vaccination status are introduced as herd replacements. These newly added susceptible, and/or infected cattle assist in keeping the infection at a relatively high rate within the herd, and pose an additional potential hazard for transmission to neighboring herds.

Lack of owner interest, regulated economic factors and lack of knowledge and motivation on the part of employees often contribute to poor management practices and low immunization rates, thus promoting transmission and increasing infection rates within and among herds. Infection rates in infected herds may range from 1% to 60% of the cattle within a herd.

In geographical areas with high cattle population densities, both infected herd rates, and cattle infection rates within herd can reach high levels unless appropriate management and immunization procedures are applied. This occurs in both dairy and beef herds. For example the dairy herd infection rate in Wisconsin in 1951, based on milk ring test reactors was 42% of the herds. In 1952, the comparable rate in New York was 62%, in Georgia 60% and in Florida 21%. In 1977, one county under area test in Florida had a beef cattle herd infection rate of more than

30%. Cumulative animal infection rates in dairy herds may be from 30 to 50%, and similar rates occur in smaller beef herds.

Infection rates are related to exposure potential and opportunities for effective transmission, which are influenced more by people factors than by biologic factors. In 1977 in the U.S., 993 herds of each 1,000 herds of cattle were free of brucellosis and only 7/1000 herds were infected.

Experience in large infected Florida and Puerto Rican dairy herds has borne out the prediction of computer simulations that brucellosis is not eradicated under a management system which combines regular test and elimination of reactors, with replacement by susceptible animals in order to maintain milk production, failure to exercise sanitation methods to minimize transmission, and failure to exercise special effort to obtain vaccinated replacements. Under these conditions within herd infection rates remain high. The recent field trials in Florida on whole herd immunization (adult vaccination), combined with more specific serologic testing, confirm the California experience that this procedure will greatly reduce spread, but that improved sanitation must be a part of the management plan to optimize eradication.

Abortion Rates Among Infected Cattle

It is important to clarify the term "abortion rate", which is commonly misused. Abortion rates should not be calculated using all cattle in a herd as a denominator because all cattle in the herd are not at risk of abortion. Since only infected cattle are at risk of abortion because of brucellosis, only the number of infected cattle should be used as the denominator to compare abortion rates among herds with differing rates of infection. Since most abortion rates cited in the literature use all animals as the denominator, rates cited here are different.

Abortion rates vary according to the exposure dose of B. abortus, the stage of pregnancy, and how many times the infected cow has previously aborted. Up to 100% of infected cattle may abort under experimental conditions, and abortion rates as high as 70% to 80% among naturally infected cattle have been reported. However, if the exposure dose is low and/or the cattle are not pregnant at the time of infection, total abortions may range from 0% to 10%. A majority of infected cattle abort only once, from 0% to 25% abort twice, from 0% to 12% abort three times, and from 0% to 5% abort four times, as reported from studies of infected herds for up to nine years. Abortion rates among experimentally infected cattle were similar for vaccinates and non-vaccinates in most reports, but a few studies of natural transmission to 30% fewer abortions were reported among infected vaccinates compared to non-vaccinated infected controls.

Abortions are an important biologic factor in perpetuating brucel-

losis since aborted fetuses and placentas, as well as newborn calves, are a primary source of B. abortus for transmission of infection, and because abortions are usually unexpected. Since abortion occurs only after infection, abortion due to brucellosis can best be prevented by preventing infection of cattle.

Duration of Infection and Shedding of B. abortus

Brucellosis is a chronic infection. Most cows which become infected remain infected for life. Some cows, particularly those exposed when young, and particularly if the exposure is prior to pregnancy, recover, eliminate the infection from their bodies and do not retain a serologic response. Cows which have the appropriate serologic response are judged to be infected because nearly all cows with appropriate serologic responses have been found to be infected, on the basis isolation of the organisms from culturing of milk, fetus, placenta and, after slaughter from lymph nodes and other organs.

Infected cattle shed B. abortus in milk intermittently or continously for as long as one or more quarters of the udder remain infected. A 17 year old cow was shown shedding B. abortus in milk 15 years after initial exposure in an infected herd. Infected cattle also shed B. abortus from the uterus, reproductive tract and with the living calf for as long as infection remains in the reproductive tract. Infection will often localize in regional lymph nodes and the udder, and persist with reinvasion of the pregnant uterus. In some cows the reinvasion may not occur regularly and such animals may not shed the organisms at time of calving. This is not predictable and such animals may shed B. abortus intermittently.

Absence of clinical disease in many cows after the first abortion, and the long duration of infection, allow infected cows to serve as reservoirs and sources of infection for long periods of time. These characteristics of bovine brucellosis pose important problems for control and local eradication, because people do not recognize these carrier cows to be sources of infection for both people and animals. They need some visible sign of disease before they understand the dangers posed by the infected cow. Until educational efforts help people to become aware of the hazards without visible signs of disease, these factors will continue to hinder the control and local eradication of brucellosis. Sufficient knowledge is available, but the people who need to use that knowledge may not have it, or in some cases may not have the motivation to take the precautions necessary to prevent spread of infection from that healthy-looking, but infected, cow.

Biologic Factors Which Influence Diagnosis

After careful evaluations, it has been concluded by four groups of experts that there is sufficient knowledge available to provide adequate diagnosis of brucellosis to achieve local eradication as observed in individual herds, in counties, in certain states and in other countries,

using appropriate diagnostic information. However, there are biologic factors which presently serve as barriers to accurate diagnosis, and all agree that additional knowledge from research could improve diagnosis, with a positive influence on the economics, as well as the ease and the rapidity of achievement of local eradication. In addition, economic and people factors influence present procedures and methods for diagnosis, often unfavorably and inappropriately, more than any inherent defects in the methods themselves. In other words, people are not necessarily using all the knowledge they have; what they do use, may be used inappropriately, and many people are not aware of the knowledge that is available.

Diagnosis of brucellosis is a complex problem similar to the diagnosis of other diseases of people and animals which (a) have variable incubation periods, (b) have limited clinical signs, such as abortion, (c) have a high proportion of clinically inapparent cases which can transmit the infection, and are best detected by a combination of diagnostic procedures, including history, serologic and cell-mediated tests, bacteriologic culture and epidemiologic evaluation. The accuracy of diagnosis is relatively the same as for other similar diseases of animals and people. This accuracy varies from place to place, and time to time, depending on the people involved in making the diagnosis, the circumstances, the history of the cattle, the needs, the economic factors, the available data and the quality of the laboratory.

Serologic tests are valuable aids in detecting brucellosis infection in cattle, but they must be applied accurately and interpreted intelligently with as much epidemiologic data as can be obtained. When other data, including other tests are not available, or are to costly to obtain, then the single serologic test result may be the only criterion for making a diagnosis, based on accepted standards. However, a single negative serologic test result, at one point in time, is not adequate to say that a cow has not been infected or exposed, since the time of testing may well be during the incubation period and before a serologic response has occurred.

In recent years there has been considerable misunderstanding and some controversy about the appropriate use of some of the serologic tests for brucellosis. People fail to recognize that each test has advantages in certain situations and disadvantages in others. The tests must be utilized and interpreted within that context.

A careful review of data on all the presently used tests, makes it apparent that there is not a single ideal test, and that there is a need for continuing support for research to develop new aids to diagnosis. It is also clear that the present tests, if appropriately utilized and interpreted, can be very effective.

To provide greater effectiveness and efficiency, a combination of screening and supplemental serologic tests should be used when time and

economics permit.

The usefulness of the "Card" test in quickly identifying animals of unknown status that may be infected with B. abortus is recognized. This fulfills a need in situations where time, or economics, or facilities will not permit supplemental tests. In these situations, with the concurrence of the owner, the Card test should continue to be used as the definitive test for classification of "Reactors" as specified in the U.M.&R. However, in all other situations, and whenever requested by the owner, the Card test should have the same status as the other "Buffered Antigen" screening tests. As appropriate, these screening tests should be supplemented, preferably by the Complement Fixation Test or the Rivanol test, to provide additional information to aid in diagnosis. The Complement Fixation test is considered, when appropriately conducted, the supplemental test of first choice in terms of balance of sensitivity and specificity. The Rivanol test, when appropriately conducted, is considered the supplemental test of second choice, but it can also be used in situations where serums are not suitable for the C.F. test or facilities are not available. The Commission recommends that the C.F. test should be available and appropriately conducted in all state labs or in regional laboratories, as necessary to fulfill the needs for this supplemental test. These recommendations will aid veterinarians and epidemiologists in developing data to make the best possible diagnosis with the available information. Research on new tests appears promising, and these should be added to the armamentarium of the laboratory, the veterinarians and the epidemiologists as these new tests are developed and approved. Research is also needed for automation of tests to develop procedures to examine one sample of blood with multiple antigens, to determine previous exposure experience as part of sero-epidemiologic and surveillance studies. Automation and multiple use of blood samples could markedly reduce costs for brucellosis surveillance.

Vaccination with Strain 19 B. abortus vaccine may cause serologic reactions which are indistinguishable from those caused by field strain B. abortus infection. This problem has largely been overcome on a herd basis, by using status of herd of origin, history of possible exposure, supplemental serologic tests, lymphocyte stimulation tests, other new tests, bacteriologic culture if possible, and then evaluation of the data to arrive at a diagnosis.

Accurate diagnosis of infection in the individual cow means that not only must the laboratory do its job, but so must everyone else. This includes accurate identification of the cow and the serum sample, proper collection, proper shipment to the laboratory and proper records for traceback to the herd of origin. All of these need to be improved, but particularly the identification of the cow, the serum sample and records for traceback.

Continuing education and training appear to be necessary to help people in the laboratory in conducting serologic and other new tests to

aid in diagnosis of brucellosis. Field personnel also need continuing education and training to help them in interpreting and evaluating laboratory and field data. The institution of an effective quality control check system has become standard in most public health and hospital laboratories; its use in the brucellosis program is indicated.

Biologic Factors Which Influence Vaccination

After evaluation, it has been concluded that available knowledge about use of Strain 19 vaccine, has been adequate, when appropriately applied, to provide major assistance in the prevention and control of bovine brucellosis toward local eradication in herds, counties, states and other countries of the world. However, biologic factors associated with development of transient and persisting postvaccinal serologic titers have served as barriers to full implementation of vaccination. Continuing and expanded research on reduced dosage of vaccine and routes of administration appears to be providing new data on vaccination that will enhance ease and rapidity of progress toward local eradication.

Vaccination is often perceived as a 100% protection for people or animals against most diseases. People have come to expect not only 100% protection, but no disadvantages or unwanted side effects from vaccines. Yet these expectations are not in accord with reality. Although smallpox has been virtually eradicated from the earth, the vaccine was a crude product derived from calves, which was not 100% protective, and it had disadvantages, including causing illness, disability and death in a small number of people. Poliomyelitis vaccine does not protect 100% of the people and appears to be responsible for a few cases of clinical poliomyelitis each year. Influenza vaccine may protect only 50-70% of recipients and it too is associated with a low prevalence of some side reactions.

Vaccines to prevent brucellosis, share many of these same characteristics. None of them protects 100% of cattle under all conditions. Protection depends not only on the vaccine and the immune response of the host but also on the dose and infectivity of the challenge to the vaccinated calf or cow. For example, Strain 19 *B. abortus* vaccine may provide 95-99% protection if the challenge dose is small and the cattle are not pregnant at time of challenge. Thus, protection is dependent on biologic factors affecting both the infectious agent and the host as well as the characteristics of a given individual batch of vaccine.

People also often perceive vaccine as a panacea and say, "Oh, if only we had a vaccine that gave 98% or more protection and was very safe, everyone would use the vaccine." People said this about poliomyelitis in 1958 and yet in 1974 less than 30% of the population in some areas of the U.S. had been vaccinated with the very effective Sabin vaccine. Thus the biologic efficacy of brucellosis vaccines ultimately depend on herd owners who make the decision to increase or decrease the number of animals that are vaccinated. Biologic factors affect use of

vaccine but the owner's perceptions and understanding of these biologic factors are also important in the decision process.

Published research on B. abortus vaccines, Strain 19, Strain 45/20 and Strain H-38 has been well reviewed and discussed at the Texas A & M University Symposium (1976), at the 81st Annual Meeting of the U.S. Animal Health Association in 1977, and by the Subcommitttee on Brucellosis of the National Academy of Sciences (1977). These Reports and Proceedings are readily available for reference and review of detailed data which will not be repeated. However, some comments of this Commission regarding vaccines and vaccination are presented in the next few paragraphs.

Strain H-38 vaccine has been studied by several investigators. In the original French studies as well as in recent studies, the H-38 vaccine was comparable to Strain 19 as an immunogen when administered in two spaced injections. However, H-38 stimulated persistent serologic titers which were indistinguishable from those caused by field strain infection. The vaccine also produced large, persisting, granulomatous masses at the site of inoculation of the vaccine. For these reasons, the vaccine is not recommended for consideration for use in the U.S.

Strain 45/20 and Strain 19 vaccines have been studied by many investigators, and both are produced commercially and sold in many countries of the world. Each vaccine has several advantages and disadvantages.

Strain 45/20 is a killed vaccine which can be stored and handled under adverse conditions, while Strain 19 is a living, lyophilized vaccine which must be stored and handled at 4°C (40°F) or less. Storage and handling is easier with Strain 45/20.

Strain 45/20 can be used to vaccinate cattle at any age except those under six months, while Strain 19 is recommended for use in calves 3 to 6 months of age (although regulations permit its use from 2 months to 10 months of age, and also in adult cattle in infected herds with special permit). At present 45/20 does not have the age restrictions on use that are required for Strain 19 (in countries where Strain 45/20 is being used).

With 45/20, herd immunity can be induced in two to three months. Because of present age restrictions for use of Strain 19 in non-infected herds, it may take 5 to 7 years to achieve whole herd immunity.

It has been documented in controlled experiments, that a single dose of Strain 19 vaccine provides protection for more than five years. Similar experimental evidence for 45/20 shows protection for two years, and all present recommendations are for two initial doses of 45/20 vaccine with a booster dose recommended every 12-18 months thereafter.

Strain 19 and some lots of 45/20 appear to provide about the same protection to similar experimental challenge doses of B. abortus.

Strain 19 does not induce a persisting local reaction while 45/20 produces a long-lasting granulomatous local reaction which may be unsightly and unacceptable to many cattle owners.

Strain 19 is a smooth strain which produces agglutinating antibodies indistinguishable from those induced by infection with field strain B. abortus, while Strain 45/20 is a rough strain which should not produce agglutinating antibodies. Thus, Strain 19 antibodies may interfere with serologic tests for field strain infection, while Strain 45/20 antibodies should not. On these points there are differing data and considerable controversy. Reports from Australia, France, Britain and the U.S. indicate that there is considerable variance among "lots" of 45/20 vaccine purchased from commercial companies. It appears that many of the cultures of Strain 45/20 are unstable and produce a mixture of smooth/intermediate and rough colony types. Thus some 45/20 vaccine does induce production of antibodies which interfere with both agglutination and complement fixation tests. Dr. Plommet at the Texas A & M University Symposium said: "In our country 45/20 has been used for many years, but if I could and had the power to do it, I would prohibit its use because we have too much trouble with this vaccine. There are big differences from one batch to another in serologic conversion, and even in the degree of protection. In my opinion, a good vaccine should first be constant in production and until now, most manufacturers are unable to get constant batches of 45/20. And, the second point is that any good vaccine should have a good method of control of efficiency. And as far as I know, there is no such method for 45/20".

Strain 19, being a live vaccine, may in one of every 100,000 calves vaccinated, induce a chronic infection of the udder, while 45/20 is a killed vaccine and does not infect the animal.

People may become infected with Strain 19 by accidental inoculation with a syringe subcutaneously, or by a spray from the syringe into the eye. Disease resulting from these accidents may vary from a hypersensitivity reaction, to mild to moderately severe illness. Strain 45/20 does not cause infection but accidental inoculation of vaccine may cause the same type of local granulomatous reaction in people that is seen in cattle, or a hypersensitivity reaction in previously sensitized individuals.

From the above discussion of advantages and disadvantages of the presently available vaccines, the preponderance of evidence rejects the use of Strain H-38. The evidence indicates that Strain 45/20 has an advantage in being a killed vaccine that withstands adverse handling and storage and has an advantage in being utilized to vaccinate a whole herd at one time (except calves less than six months old), but 45/20 also has a number of disadvantages. Several disadvantages which completely over-

ride the advantages at this time are the observations of Dr. Plommet of France and others in Britain and the U.S. regarding the "big differences from one batch to another in serologic conversion and even in the degree of protection". Thus the evidence supports the conclusion, that 45/20 should not be recommended for use in the U.S. for control toward local eradication, until such time as stability and consistency of the vaccine batches have been established to be satisfactory and with minimal or no interference with serologic or immunologic tests that may be utilized in the diagnosis of brucellosis.

The evidence indicates that Strain 19 vaccine has a number of advantages and does offer a reasonable degree of protection against infection. The degree of protection may be described as approximately 70% complete protection, for an average of all controlled USDA experimental studies, and up to 95% protection in field situations where all cattle in the herd are vaccinated and exposure doses may be lower. However, Strain 19 has had two disadvantages. These are (1) restriction of age of vaccination to 3 to 6 month old calves as the recommendation of choice, with an alternative of vaccinating calves from 2 to 10 months, as a compromise with management and husbandry practices; (2) development and persistence of postvaccinal serologic titers, which at a single point in time could not be readily distinguished from serologic titers due to field strain infection. These two disadvantages have imposed restrictions which have limited the use of the vaccine by many cattlemen and have led some regulatory officials and industry leaders to discourage vaccination even in high prevalence areas. Strain 19 vaccine has been shown to be of great assistance in reducing infection within herds in states such as California, Montana, Wisconsin, North Dakota and New York, but for some people the disadvantages were too often perceived as greater than the advantages. Thus the disadvantages have resulted in reduced vaccination levels, and have hindered achieving levels of protection needed to maximize progress toward control and eradication.

Research is essential to provide improvements in present vaccines or to develop new vaccines, as for example using specific fractions of the bacterial cell to provide greater specificity and greater protection.

In the meantime, the disadvantages of development and persistence of Strain 19 residual titers are being minimized by knowledge of history of herd of origin, use of supplemental tests or other new tests, and appropriate interpretation of results. More importantly, research to investigate reduced doses of Strain 19 vaccine and alternate routes of administration appear to be providing data which will allow vaccination of older cattle and which will greatly reduce interference with serologic titers for field strains of _B. abortus_. Reducing vaccinal titers, to a level where they will seldom interfere with serologic tests for field strain _B. abortus_, would also allow serologic testing of cattle over 15 months of age regardless of vaccination status. This would make "test eligible" the vaccinated heifers which are presently exempt from

test between 12 and 24 months of age to avoid vaccine induced titers. If vaccinated heifers could be considered test eligible at 15 months of age, it would remove another reason for spread of brucellosis; the lack of surveillance of vaccinated cattle between 15 and 24 months of age to detect the infected heifers prior to calving or abortion.

The recent work on use of reduced doses of Strain 19 in adult cattle in infected herds in high prevalence areas, emphasizes again that it can be extremely helpful in reducing the exposure potential and rate of spread within such herds, but vaccination cannot be depended upon as the sole tool to be used in freeing herds completely from infection. Studies on whole herd vaccination of herds not infected but faced with a high risk of exposure, would be extremely useful. This type of "ring vaccination" strategy around foci of severe infection has been very effective in foot and mouth disease and human smallpox eradication campaigns. It must, however, be coupled with effective quarantine, removal of identified infected animals and other management and sanitary measures in a local eradication system.

These research efforts involving vaccine and vaccination need to be continued and expanded so that vaccination can be used in accord with the needs of industry for protection of cattle and the reduction of infection as progress is made toward local eradication.

CONCLUSION

In summary, the Commission finds that biologic knowledge essential to accomplish local eradication of brucellosis is available. Although there are biologic factors which appear to pose partial barriers to achieving control toward local eradication, none of these biologic barriers appears to be insurmountable, and in fact they have not prevented achieving local eradication in herds, counties and states in the U.S. and in other countries of the world. Additional knowledge from continuing support of research will also aid in providing new data to solve new problems as they arise and provide data for increased effectiveness and efficiency.

Public Health Factors Influencing Policy Options

Brucellosis spreads from animals to human beings. Transmission from person to person rarely if ever occurs. Infection of people results from exposure to infected animals, primarily beef and dairy cattle, swine, and goats and their products, raw meat, unpasteurized milk, cream, cheese, ice cream and yogurt.

Human illness from brucellosis occurs with highest frequency in occupational groups who have exposure to animals. These include owners and their families, farmers, packing plant workers, meat inspectors, employees of the livestock and dairy industries, veterinarians, and consumers of raw meat, unpasteurized milk and other dairy products made from unpasteurized milk.

Brucellosis in people results in economic loss and decreases productivity, which can be quantitated. Brucellosis also results in pain, suffering, and in some instances death can result, the cost of which cannot be easily measured.

Prevention of the disease in human beings is dependent upon (1) elimination of brucellosis in animals, (2) prevention of the transmission of the micro-organism from animals to people and/or (3) increase in the resistance of people who are at increased risk of exposure.

Important in the process of prevention of human brucellosis is education of many people in order that they may understand the epidemiology of the disease and be able to prevent it. This is particularly true for those who are responsible for decision making, industrial processes, movement and marketing of animals, and for the workers in the livestock, dairy and meat packing industries as well as consumers of animal products.

The prevention of human brucellosis and the maintenance of human health is one of the most important issues to be considered in the processes of decision and planning whether something or nothing is to be done about this disease. The issue of human health is a constraint against the philosophy of doing nothing and is a force leading to a program of control with eventual eradication of the disease from animals. If we eradicate brucellosis from animals in this country, we will protect all people except those who travel to, or consume contaminated foods from countries which harbor infected animals. From the standpoint of human health as the sole issue, global elimination of brucellosis is desirable and logical.

Packing house employees are presently the occupational group with the highest reported incidence of brucellosis and there is no successful program to protect them from exposure to brucellosis from infected ani-

mals presented for slaughter. As the prevalence of bovine brucellosis increased within the past 5 years, reported cases in people caused by *B. abortus* also increased in proportion.

Two states have instituted regulations restricting import of branded reactor cattle for slaughter with the aim of protecting workers, and packing house infections are under investigation in other states by state and local health departments and the Center for Disease Control. The Commission believes that it is realistic to consider seriously the prospect that Occupational Safety and Health standards for reactor cattle may be imposed in the packing industry, at some time, unless a plan is in effect to reduce the hazards to employees through local eradication of animal brucellosis. Serious considerations must also be given to the prospect of imposition of consumer protection standards on processing reactor cattle comparable to those which are presently in force requiring cooking of branded tuberculin reactor cattle, or cattle or swine with lesions of tuberculosis.

Approximately one fifth of the reported cases of human brucellosis occurs in workers in the livestock industry. When infection exists in a herd, there is opportunity for acquisition of the microorganisms from blood, milk, aborted calves, placenta, amniotic fluid and other tissues of the infected animals. There is not now a structured system either to protect from, or to compensate for, illness and disability occurring in members of farm families, employees or private veterinarians who are at risk of infection.

Although the prevalence of the disease in animals has been greatly reduced, human infection still occurs. It has been observed that as the incidence of possible hazard is reduced, people take fewer precautionary measures. Each worker in the livestock industry should be educated to the hazards of the zoonoses. The Commission believes that one effective means of such education would be the notification of the State Human Health Agency, by the State Animal Health Agency, of the imposition of each herd quarantine for brucellosis. The Human Health Agency could then send educational material to the herd owners, which describes the risks of brucellosis to themselves, their families and their employees, as well as the precautions which should be taken to protect all those at risk.

Sending such notification to the County Health Officer, Public Health Nurse, and County Medical Society would be a useful mechanism to insure follow up for prevention and case-finding. These procedures are presently being followed in some states and could have a significant effect if applied more generally (Appendix A, page A-67).

The Commission's own survey of State Epidemiologists, supports the recently published survey by the Center for Disease Control that there is great variation in the serologic testing procedures and criteria for diagnosis of human brucellosis in public health laboratories. Attention should be given by the State Health Departments to the procedures recommended by the CDC (see Appendix A, page A-8).

Section 4.6 Constraints of Information and Assumption of Responsibility

Effective control of bovine brucellosis, and particularly if the goal of that effective control is local eradication becoming national in scope, is achievable only on the basis of steady progress through sustained effort and achievement. Experience in the 1950's and 1960's, in those states where herd prevalence rates were brought from as high as 50% to less than 0.1%, shows that that kind of progress depends upon understanding the nature of the disease, and of the programs designed to control it.

Knowledge and understanding of the disease, and of the programs is required by all who have any role to play in the complex systems of production, transportation and distribution, marketing, and regulation of livestock and their products in this country. The people who must be knowledgeable include not only producers, their private veterinarians, state and federal regulatory veterinarians and livestock inspectors, but also those who are engaged in service to these groups. Such people as livestock or milk handlers, auction market operators, cattle dealers, order buyers, packers, meat inspectors, county agricultural agents, public health officers, all have a need to know.

They need to know about the disease, and how it relates to their own individual part in the chain of production and distribution. Most importantly, they need to know their own responsibilities in preventing transmission, and it is clear that without this understanding, their willingness and ability to assume those responsibilities will not be forthcoming.

The National Academy Committee, on page 37 of its report, recognized the importance of dissemination of factual information about the disease and the drawing up of plans for eradication which are explained to each producer and owner.

As the Commission has traveled through the country, examined position papers, received testimony at its hearings, and delved into program statistics, we have been particularly impressed at the extent to which important, well established facts about the disease and the program are not being distributed to those who need most to know. It is disturbingly impressive to see the extent of failure to assume responsibility for adequate training and public education programs.

There appears to be a sort of Gresham's Law of education which says that inaccurate or incomplete information drives out the accurate and factual. In the absence of well designed, accurate information programs, which are specifically targeted to the needs of particular localities and of specific groups, inaccurate and incomplete information circulates, and conflicting advice is given, to the detriment of control programs.

We do not intend to make a detailed listing of all of the deficiencies in training and public information programs which we have encountered. Also, we do not wish to imply that there are not adequate training and public education programs operating anywhere in the country. This is clearly not so. We will, in this section, detail a number of kinds of information needs, some examples of deficiency in furnishing it, and the impact of those deficiencies on the program. We also give examples of programs which appear to be producing the desired effects, to serve as a basis for recommendations.

Although some of the discussion which follows may seem to be repetitious of material also presented in Section 4.4 on biological aspects of the disease and program, we feel that reinforcement of the concepts, as they apply to public information programs, is useful.

Bovine brucellosis has certain general epidemiologic features which, properly understood and applied, make effective control a relatively straightforward matter. The first important feature is that brucellosis is a herd disease. Within an infected herd, transmission is usually by direct and indirect contact of uninfected susceptible cattle with the products of an abortion, or of an apparently normal calving by an infected cow. At any point in time, an infected herd will consist of three groups of animals. First, there will be infected animals, which react to the serologic diagnostic tests and are capable of transmitting infection to the second group of animals, the uninfected but potentially susceptible cattle. They will be uninfected either because they have not yet been sufficiently exposed, or because they are resistant. Finally, the herd will contain a third group of animals which have been exposed, and have become infected, but do not react to the diagnostic tests.

This group of infected, non reacting cattle, those in the so called incubation stage, are the most important in terms of their potential as transmitters within the herd, or to other herds. While the incubation period on the average, is 1 to 2 months, some animals, especially if they are exposed just before, or early after breeding, will have incubation periods of 4 to 6, or even more months. Some of these animals may not react until after abortion or calving, and so will have been undetected until after the most dangerous time in terms of transmission.

Movement into a clean herd of such exposed, infected animals from a herd not yet known to be infected, after a negative test, for example at a sales barn, is an almost unbeatable way of infecting the second herd. But this is permitted in many states under the minimum standards of the U.M.&R. The educational campaign with its slogan "Don't buy brucellosis" doesn't adequately inform, and it helps to create the mistaken impression that the negative test at the sale was a sufficient indication that the animal was free of infection.

Again and again we have heard producers express their bewilderment on the source of infection in their herds, because the only animals they

had purchased were "negative at the sale". Educational material directed at producers whether distributed by APHIS Information Services, or in books on animal hygiene, emphasize the importance of a single test at purchase, and either do not mention the incubation period, or pass it over lightly.

The minimum standard for release from quarantine in the U.M.&R. has gone through a succession of changes from 1943 through 1975. During the period from 1959-1967, when most states were conducting initial area tests for modified certification, the quarantine could be raised with only a single test first at 30 days, and then 60 days, after removal of the last reactor. Although from 1943 to 1958 two tests were required, the decision to amend the U.M.&R. in 1959 to require only a single test was not unreasonable. During the 1950's a number of factors converged to make it possible to free a large proportion of the infected herds with a relatively small number of tests and the short quarantine period. Large numbers of herds in a county, several counties or whole states were being tested in a relatively short period of time. Average herd sizes were smaller then they now are, vaccination was being practiced much more generally, which limited the spread of infection, and most of the population under consideration was either dairy cattle under ring test surveillance, or beef cattle in the Northern Great Plains and Mountain States with seasonal calving.

As these areas moved from modified certified to certified free status during the 1960's, a relatively small number of problem herds were discovered which posed real difficulties in becoming free from infection. Out of the problem herd investigations, came the recognition that prolonged incubation periods and premature release of infected herds from quarantine were responsible for residual infection. Movement of animals from such herds, especially into areas of low prevalence is associated with substantial risk.

Based upon this epidemiologic background, the requirements for removing quarantine were changed in the U.M.&R., in 1972, to two negative tests, with the second test 120 days after removal of the last reactor. Clearly, the long incubation period in brucellosis is the reason for this long quarantine, but our investigations in the field make it clear that this is not adequately explained to the producer, and often is not fully understood even by those responsible for implementing the quarantine policies.

Another area in which there is great opportunity for misinformation and misunderstanding is what can, and cannot be expected from vaccination with Strain 19. In our hearings and field trips, we found that individuals make their decisions on whether or not to use (or to recommend) Strain 19 either on the idea that all vaccinated animals are protected animals, or that the widely cited 65 percent protection rate is just not good enough. These are simplistic treatments of a complex problem, and public information programs which are not specifically

designed to respond to the individual herd owner's concerns are inadequate. Protection in the field is usually better than 65 percent, and transmission is retarded within vaccinated herds. On the other hand, not all vacciantend animals are protected and this must be understood if management is to be based on knowledge.

Epidemiologically, a much more important kind of misinformation arises from the persistence within the minimum standards of the U.M.&R. of the exemption from test of calfhood vaccinated animals up to 24 months of age for beef animals. This exemption carries with it the implication that if such animals react to the serologic diagnostic test it is a residual Strain 19 reaction. This implication is not uniformly correct and results in spread of infection. The practice arose, of course, in order to accomodate to the partially conflicting aims of trying to increase resistance to infection by vaccination, and at the same time to increase surveillance through the market cattle testing program. Education programs must be targeted so that producers, marketing agencies regulatory agents and private veterinarians can arrive at decisions on a more rational basis. There are options available which involve age at vaccination, intelligent use of supplemental tests at earlier ages, and intelligent application of epidemiologic information to individual herds and to populations of herds.

Producers and their veterinary advisors must be made aware that vaccinating 10 month old heifers, that are really yearlings, will convert them into long term card test and standard agglutination test reactors. They must understand that application of supplemental tests, such as the rivanol test or complement fixation test, can resolve the infection status of such animals, if the tests are applied at 2 points in time and preferab'/ against the background of a known herd of origin. Infected, presumably officially vaccinated animals move in trade channels without test, and they have a compound interest effect in spreading brucellosis.

The foregoing is just a short list of examples of kinds of information, understanding of which is essential to assumption of responsibility. We have indicated earlier, the disturbingly impressive extent of failure to train specifically for assumption of responsibility, and wish now to document this with a limited number of examples.

A review of the major texts used to teach microbiology and infectious diseases in American veterinary schools shows that the important epidemiologic features of the disease are inadequately discussed. In addition, information on vaccination, on supplemental serologic tests and on program details is either scanty, inaccurate or lacking. The private veterinary practitioner, with this kind of training in veterinary school, and who may never have been involved in the organized program, is nevertheless looked to by his producer-client as the most dependable source of information (Appendix C). Our files show that the producer's confidence often may be misplaced because of the frequent

failure of practitioners, in both high and low prevalence areas, to entertain brucellosis as a primary possibility in differential diagnosis of bovine brucellosis. The effects of that failure has been compounded by examples of state diagnostic laboratories and veterinary school referral clinics concentrating on diagnoses such as leptospirosis or IBR, without even doing a serologic or bacteriologic examination. For example, effective action in response to the reintroduction of virulent infection was delayed in at least one herd in New York, when brucellosis was not considered in submission of several aborted fetuses to the laboratory. Corrective action taken in New York state, includes both the distribution of an abortion kit to practitioners, as well as educational reminders. We visited a Texas ranch, at which after the first 5 abortions among recently purchased heifers, the telephoned veterinary advice was to switch from the 3 serotype leptospirosis bacterin to the 5 serotype bacterin. It was not until after the 12th abortion, when the rancher loaded all 12 of the cattle, hauled them to his practitioner's clinic, and suggested that they be tested for brucellosis, that the correct diagnosis was made.

Accredited veterinarians in private practice do function in the cooperative state-federal program, in collection of blood samples at markets, on farms and ranches, for forwarding to the state laboratory for official tests, in the execution of health certificates for interstate shipment, and in official vaccination. Successful completion of an examination is a requirement for accreditation, but there is not a structured program for continuing education of accredited veterinarians, to keep them abreast of new information on the biology of the disease, and of the significance of changes in regulations.

This is not to imply that there is no educational communication between regulatory professionals and accredited private practitioners. Programs of high quality do exist, but they depend entirely on the ability, inclination and availability of time of the Regional or Station Epidemiologist, particular V.M.O.'s in the Federal force or of the State Veterinarian and his staff on the state side. Only rarely do the Extension Veterinarians on the Veterinary Schools become involved in this aspect of continuing professional education. Thus, the private practicing veterinarian, to whom most producers look for advice, has inadequate opportunities, in most states, to fully develop and employ his professional skills in the brucellosis program.

The Regional and Station Brucellosis Epidemiologists are all well trained, knowledgeable and articulate experts, but it is our distinct impression that they are stretched too thin to maintain continuing training programs in their areas without the impetus of a major program push. For example, in preparation for the accelerated program in Tennessee, an excellent coordinated information program was mounted. This involved the Regional and Station Epidemiologists, the State Veterinarian and his force, and the county agricultural agents. In contrast, in some of the states which are approaching certified free status there is an assumption that people are aware both of aspects of

the disease and of the requirements of the program. Neither assumption is necessarily valid for producers or veterinarians who are too young to have had experience of brucellosis during the higher prevalence days.

In some of the high prevalence states, there has been an abdication of responsibility by the Extension Service because of the "controversial" nature of the brucellosis eradication program. In some of the very low prevalence areas there has been a false sense of security which has led to giving brucellosis a lower priority for educational and extension resources than it deserves.

The training program for APHIS Veterinary Medical Officers (VMOs) includes a one week brucellosis epidemiology short course. State-employed veterinarians are eligible for, and some (but not enough) do receive this training as well. The course is a good one, but without reinforcement on a programmed basis, it cannot be counted upon to keep the field force sufficiently knowledgeable to be expert sources of information. However, the VMOs have responsibility for all Veterinary Services programs in their areas, and these supervisors must choose among a large variety of training opportunities to which to assign them.

The federal and state-employed livestock inspectors also are responsible for many program details, and have extensive contact with producers, market operators and transporters. They should be knowledgeable about the biology and epidemiology of the disease, within reasonable limits. While there is provision for local training of the inspectors with their VMOs, under the direction of the Station or Regional Epidemiologist, this is often limited in extent. Because of the high rate of turnover of this category of program employee, and the exigencies of program objectives, they are often less knowledgeable than would be desirable.

As indicated above, the Regional and Station Epidemiologists who have received extensive specialized training, and have continued to broaden their experience in the field, are a great strength of the program. Unfortunately for the program, a significant number of them have elected to take administrative training, and some have moved into administrative positions. This is understandable in terms of their own career opportunities. The Regional Epidemiologist must move into the administrative career ladder if he is to advance further in Veterinary Services. There is also logic in the argument that such well trained people should be administering the program. However, it also results in loss of some of the most technically knowledgeable people from direct contact with the field aspects of the program, and it has been difficult for Veterinary Services to fine qualified candidates for the training programs.

The Public Health section of this report documents the extent of the lack of communication between public health and animal health

officials which exists in many states (Appendix A). This includes failure to communicate on the finding either of cases of human brucellosis, or the finding of new infected herds of livestock. It also includes confusion or lack of communication on which public agency bears the responsibility for enforcement of a Grade A milk ordinance within a state or market. All of these breakdowns of communication have obvious implications for success or failure of program objectives. They are in sharp contrast to a level of intercommunication which characterized program activity in all parts of the country during the 1950's and early 1960's.

Section 4.7 Political and Legal Constraints Imposed Upon Policy Options

Competing interests exist throughout the nation with respect to brucellosis control and eradication. These interests are expressed with varying degrees of vigor and effectiveness through the political process at local, state, national and even international levels. The political messages are conveyed directly by individuals, or through organizations which represent their interests, and by lobbyists specifically engaged to present points of view.

Analysis of the official position papers submitted to us, and to the Congressional Committees, as well as the responses in our survey of State Veterinarians, shows that the opinion that eradication is feasible, and depends upon strengthening and rigorous enforcement of existing regulations, is held primarily in the "Certified Free" states and those approaching that status. This point of view is expressed by both beef and dairy producer groups as well as the regulatory officials. Positions of skepticism either of biological or economic feasibility are expressed primarily by spokesmen in the high prevalence areas. This attitude is more prevalent among beef producers than dairy producer groups. They are joined by marketing agencies in calling for more flexibility in administration, to facilitate movement, usually through use of vaccine, and almost always for delay in implementation of rigorous movement controls while research is pushed on improvement of vaccines and diagnostic tests. A simple tally of position papers, testimony and resolutions places a majority on the side of eradication. However, it seems to us to be unrealistic to proceed on this basis.

The interests of individual producers and producer groups are not necessarily perceived identically. For example, individual dairymen whose own herds have become infected have exerted political pressure for solutions to their own immediate problem, such as permission to retain reactor animals to the end of the lactation. This position, adopted by individuals, is contrary to official positions of such producer and product marketing organizations as AMPI, to which they belong. It is, of course, also contrary to the provisions of the Grade A milk ordinance. Similarly, within the beef cattle producer group, there are geographically different interests, such as those of the cattle stocker-feeder exporters of the Southeastern states, compared with the interests of the Upper Midwestern or California combined cow-calf-feeders who import animals. Market operators in their turn express their concerns over the costs of regulation, and with interference with opportunity to move cattle into the most profitable channels.

Consumer interests, expressed through political channels, have a strong influence on these decisions. For example, the recently increasing consumer demand for raw milk and raw milk products carries with it the requirement that those products shall be from brucellosis-free animals. The clear association between human brucellosis in abbatoir

workers, and the prevalence of infection in cattle was used in 1977, in Wisconsin and Pennsylvania, as the rationale for the imposition of regulations which limit import of known brucellosis infected cattle for slaughter into those states. The California brucellosis legislation specifically designates the public health hazard as the rationale for the decision to eradicate the disease in that state.

After it was established in 1977, that imported Canadian cattle reintroduced bovine brucellosis into New York and Vermont, the political process was employed to impose additional federal regulations on import of cattle from the Eastern Canadian Provinces into the U.S.A. It is interesting that these new federal regulations, which are epidemiologically sound, are also far more stringent than those which are imposed between the modified certified and certified free states under the U.M.&R. Their adoption, and extension to all of the Canadian provinces, was vigorously supported by representatives of groups which at the same time argue for greater flexibility of movement within the U.S.A. Obviously while such regulations serve to protect the brucellosis-free areas of the U.S., they also act as a trade barrier. They impose an economic disadvantage on Canadian cattle owners, and provide an economic advantage for cattle owners and dealers in modified certified areas of the U.S., who do not now have to meet the stringent requirements in order to compete for the same market. This episode illustrates the fact that the adoption and modification of the U.M.&R. is also an example of the political process at work, in trying to accomodate to multiple competing interest groups. It is noteworthy that Canadian regulatory officials see the new regulations as supplying an incentive for compliance by Canadian producers and dealers with their national eradication program.

The application of the political process in the modifications of the U.M.&R. has also resulted in the adoption of rules or standards which are epidemiologically unsound for an eradication program, if other factors are not considered. For example, in 1967 and 1969 standards on exemption from individual animal health tests for movement into or within Modified Certified Areas were relaxed. The first change was one of wording, exempting cattle from "herds [of origin] not know to be affected", compared with the previous standard from "herds known not to be affected". The second such change was the adoption of the exemption from test of officially vaccinated beef cattle up to 24 months of age. These trade offs apparently were necessary, when they were adopted, in order to enlist cooperation on other measures on movement which were seen, at the time, as being more important.

It seems clear and appropriate to the Commission that the interests of various groups will continue to be expressed politically. No one should be surprised if, in the future, labor unions, or consumer groups, or packers who are faced with rising workmen's compensation premium costs, combine politically to impose barriers or penalty payments on slaughter of infected animals. Such barriers on slaughter could also

arise from OSHA regulation in response to labor union pressure.

Similarly, it would not be surprising if political pressures were brought to bear more strongly by the major dairy production states to re-examine the administered minimum farm prices paid for milk in those Grade A milk deficit areas in which there is also a high prevalence of brucellosis in dairy herds.

The report of the Surveys and Investigations Staff, House Appropriations Committee discusses the political ramifications of the eradication vs control controversy very perceptively. Section X of that report "Control Approach versus Eradication Approach" makes it clear that assurance of adequate funding is a prime consideration in setting control-eradication strategies. The financial arrangements involved are complex, including sharing of costs by the public and private sectors, and the statutory 60-40 federal-state sharing formula. The appropriations process is subject to all of the political interactions in each of the 50 states and in the federal government. Furthermore, the requirements for these programs must compete with entirely different demands for governmental funds. We saw this in the rejection of the increased brucellosis program budget request of the Texas Animal Health Commission in the 1977 session of the Texas Legislature. Recommendations for increased funding for federal personnel which the Commission might believe to be appropriate for program needs, would have to be considered in the context of a general tendency by the Congress and administration to impose personnel ceilings on federal agencies.

Regardless of whether the program strategy adopted is "control" or "control leading to local eradication," it cannot succeed without adequate cooperation and commitment by all parties involved. At the very least, this is essential to move both necessary program authorization and appropriation measures through the state and federal legislative processes. At the operational level, such cooperation is essential for accomplishment of program goals.

It is also necessary to recognize that there is now a strong public push to reduce the extent of governmental regulation in the private sector. This may be seen in such recent actions as the U.S. Supreme Court decision on OSHA inspections, the California initiative vote on property tax limitation, or congressional action to impose flat percentage cuts in departmental budgets.

The Commission recognizes that the problems of mustering political support of all affected parties behind a program of control leading to local eradication are formidable. We also think that the political problems of maintaining support for a national control-only program, or for a program with different ultimate objectives, in different parts of the country, are even more formidable. Twenty-eight states have adopted regulations on import of cattle from modified certified or uncertified areas which are stricter than those in the present U.M.&R. States in

the low prevalence areas, which have made major investments over the past 10 to 25 years to achieve their present status, have made it clear that they are prepared to require individual herd certification as a basis for import from states with programs which do not meet the standards of the present U.M.&R.

For these reasons, the Commission feels that the balance of political constraints is on the side of a program of control leading to local eradication which is ultimately national in scope.

The Commission believes that it is useful to examine more closely the nature of the laws and regulations for prevention, control and local eradication, the processes by which they are enacted or adopted, and aspects of voluntary compliance and enforcement. The first point to be emphasized, is that the entire 45 year legislative history of the program makes it very clear that it is a state federal cooperative program. Accordingly, each of the states must enact its own enabling legislation and implementing regulations. Since bovine brucellosis is a disease not only of cattle, but is transmissible to people from cattle and then products, it has also been the subject of public health legislation in many municipal jurisdictions.

There has been enormous variation among the federal, state and municipal jurisdictions, over time, both in the requirements in their respective laws and regulations, and in the nature of their enforcement. These variations, at different times since 1934, naturally reflect the political power of such interests as the dairy and beef industries, consumers, public health advocates, and so on. Thus, the initial federal legislation authorizing tests and payment of indemnity for slaughter of brucellosis and tuberculosis reactor cattle, were enacted as a means of increasing farm income during the depression of the 1930s, as well as an aid to production of healthy livestock.

In contrast, starting in 1951, it was in response to consumer-public health political pressures that a succession of cities, and then states enacted legislation which required that Grade A milk must come from brucellosis-free cattle. Responding to the concerns both of city and state health departments and the milk marketing industry, the U.S. Public Health Service issued its 1953 Revised Public Health Sanitation Standards recommending that all Grade A milk in the U.S. should be from brucellosis-free cattle. In its successive revisions over the years, to accomodate to the greater amounts of interstate milk shipment, this standard has remained in place. As pointed out in section 4.3, it has constituted and remains the greatest single incentive to control leading to local eradication of brucellosis in the dairy cattle industry.

Dairymen who made the investment necessary to free their herds from brucellosis, exerted pressure for legislation for protection of their access to the Grade A milk market, and of the significant productivity increases which eradication from their herds produced. They recognized

that brucellosis was transmitted from dairy to beef herds and vice versa, and numerous states enacted legislation requiring all cattle herds to enter a program to become free of brucellosis. This concept of local eradication for the entire state was accompanied by a transfer from the individual cattle owner to the state (in cooperation with the federal government), of responsibility for surveillance and prevention of entry of infection at the state borders, rather than at the individual farm borders.

As is the case with any other technological advance in agricultural production, the first producers to achieve brucellosis eradication in their own herds (states or regions) achieved the greatest economic advantage, but it was of relatively short duration as more and more producers (states or regions) adopted the same practices.

Between 1940 and the present, various states enacted legislation and imposed regulations without great regard to coordination between neighboring states or among states between regions. It also appears to us that insufficient attention was paid to the epidemiologic considerations inherent in the movement patterns of the cattle industry. These two factors resulted in some states being out of phase with their neighbors or region in terms of progress toward local eradication. That is, some states achieved modified certified status earlier than their neighbors, and even progressed to certified free status while neighboring states had not been designated modified certified.

This variation in progress set in motion competing political and economic pressures among states and regions, with the "early achievers" seeking methods of protecting their gains by imposing restrictions on movement of cattle into their territory, and simultaneously capitalizing on their status by demanding increased freedom of movement for the animals they move.

These wide differences, created over time between "early achievers" and "late achievers" engendered competing pressures among the states and among regions for the adoption of modifications in the U.M.&R. and the establishment of state laws and regulations which were not in accord with knowledge of the epidemiology of bovine brucellosis, or good animal disease prevention. There are many examples of such compromises (page 4.6-2).

In section 4.9 we discuss the problem of balance of on-site and off-site costs associated with the brucellosis program, through the payment of indemnity as a positive incentive. The assessment of fines for violations of laws and regulations, and civil suit for recovery from damages are pursued as negative incentives.

As pointed out in detail in Appendix D, Page D-10, peak expenditures of federal funds for indemnity were disbursed during 1955-56, when 30 percent of total program obligations were for indemnity, and again

in 1975-76 when the percentages rose again to 27 and 35 percent ($12,821,000 in FY 1976). There is great variation in the indemnity payments by the individual states, and as pointed out in Appendix D, the role of indemnity in enlisting program support among producers has varied in different states and at different times. It is clear that administrative problems in disbursing indemnity payments which are encountered in some states engender strong antiprogram feeling. In high prevalence states, such as Texas, this has been directed against the Federal government (see Appendix C), even though all of the indemnity is from federal sources. The development of dedicated minicomputer based Brucellosis Indemnity Claims System (BICS) has reduced, but not entirely eliminated these problems (Sanders, W. M. et al., Progress Report Los Alamos Scientific Laboratory LA-7213 PR, April 1978).

The policy of making very large disbursements of federal indemnity funds in states where other program components are of relatively low quality appears to us to be questionable. We have also found that the procedures necessary to obtain increases in levels of indemnity to conform with market conditions, or to implement herd depopulation are excessively complex, and out of proportion to the incentive furnished. Low prevalence states have accomodated to this by increasing their indemnity appropriations to reflect market replacement value of animals, so that they can respond rapidly to the problems posed by reintroductions (Appendix D, Table 1.1.4).

Enforcement of the laws and regulations varies widely among the states. While it is difficult to obtain data on expenditures of funds and effort at the state level, our survey has made it clear that these efforts are not often cost-effective (Appendix D, Table 1.2.19).

Enforcement of compliance with the Code of Federal Regulations, is also a very costly aspect of the federal program. While we are unable to obtain cost data directly attributable to the brucellosis program, the FY 1977 personnel budget alone, for compliance officers in APHIS Veterinary Services, was $2.29 million. If it is estimated that between 1/2 and 2/3 of their effort was devoted to investigations on brucellosis violations, the minimum annual cost of federal compliance activity exceeds $1.5 million. This generated successful prosecutions of 33 individuals and their conviction on a total of 86 violations. They were fined a total of $14,275. While there may be some deterrent effect of the possibility of prosecution, it does not appear to the Commission that federal compliance expenditures are cost-effective. The introduction by Senator Long in the current session of the Congress, of a bill providing for administrative procedures in enforcement of the animal and plant disease provisions CFR is a step toward increasing the effectiveness of compliance enforcement.

It has been suggested in some quarters that wider compliance with the U.M.&R. could be encouraged by a system of regulations which relies on a private enforcement mechanism. That is, that dealers, and owners

who sell breeding cattle, will be encouraged to act in conformity with regulations because of the prospect that individuals will initiate legal actions against them if they do not. Those who think that a system of regulations which is dependent on the incentive of privately invoked common-law or statutory remedies may have a two-fold basis for their assessment. First, there has been publicity recently concerning successful litigation in civil suits against dealers who misrepresented the health status of their cattle. Secondly, private enforcement of regulations holds out the attractive propsect of achieving the desired objective of wide compliance without further increasing what is already perceived as an unwieldy bureaucracy.

One statutory basis under which a buyer could pursue a remedy in the event of a dealer or other seller implicitly misrepresenting the health of livestock sold, would be the Uniform Commercial Code. This was done successfully in Federal District Courts in Oklahoma and North Carolina during the past year, where it was alleged by buyers of cattle that the dealer breached an implied warranty that the cows were suitable for dairying, when they were actually infected with brucellosis.

The U.C.C. provides therefore, a potentially broad remedy for breach of implied warranty. To bring suit under 2-314, a plaintiff must show that the seller is a merchant with respect to the goods in question. Once this threshold issue is crossed, the plaintiff must show the existence of the warranty, the fact of its breach, and that the breach was the cause of the loss sustained.

While we are not aware of case law in the state courts on the application of the U.C.C. specifically to brucellosis. There is such case law which establishes that the old rule that there is no implied warranty of soundness in the sale of animals where the soundness is hidden, unknown to the seller, and difficult to discover, is no longer in effect.

In spite of the broad applicability of the U.C.C. provisions concerning implied warranties, we do not believe that it can be relied upon as a major incentive to insure compliance. The burden of bringing suit, and of proof, both lie with the complainant. In the absence of a program specifically designed to furnish proof that purchased animals were in fact infected, the outcomes of suits are unpredictable. Mechanisms with the potential of establishing such proof do exist in the requirement for a 30-60 day post purchase test for imported animals in regulations of states such as California, Montana, Wisconsin, and Missouri, among others. However, enforcement of these post purchase test regulations, particularly for beef cattle is variable, and their potential use in recovery actions is not widely enough understood to furnish an incentive to compliance.

Administrative enforcement and recovery procedures have been proposed, both at the federal and state levels, as a potentially more

effective alternative. For private recovery of damages sustained from the purchase of infected animals, such a mechanism could foster a greater assumption of accountability by sellers and handlers of cattle. It would require the enactment by states of an administrative procedures act similar to the Model State Administrative Procedures Act. Such an act could (1) provide for the issuance of cease and desist orders preventing further sale of animals by sellers found to have sold infected animals, (2) allow for a rapid fact finding adjudicatory process to determine extent of liability and who bears the loss, (3) encourage post purchase testing, (4) allow for judicial review of findings and orders.

Some states have such a procedure of administrative enforcement of regulations. For example, Ohio provides for administrative revocation of livestock dealers' licenses under certain conditions. The Commission believes that the extension of the principle of Administrative procedures to private recovery, is worthy of consideration by the states. (See Appendix I for more extended discussion).

Section 4.8 Sociological and Cultural Factors Influencing Policy Options

Epidemiologists recognize that sociological and cultural factors influence the occurrence of disease in people, and in many types of animals. It has been well demonstrated that prevention and elimination of disease in human populations may be made either more difficult, or facilitated, by certain beliefs and practices. People who drank unpasteurized milk 40 years ago were at greater risk of acquiring tuberculosis and brucellosis, compared with those who drank only pasteurized milk. People who ate inadequately heated pork were at greater risk of contracting trichinosis than those people who did not eat pork. Production systems in which chickens are kept for egg production for only 12 to 18 months, are characterized by a very low prevalence of avian tuberculosis. In contrast, people whose custom or practice is to keep egg producing chickens for three to seven years, have a high risk of experiencing avian tuberculosis as a clinical disease in their flocks. Cattle owners, whose custom is to buy and sell cattle without knowledge of the herd of origin and its disease status, are at much greater risk of introducing cattle diseases into their own herd, and of spreading disease, than cattle owners who have relatively closed herds, raise their own replacements, and do not introduce cattle from outside herds except with care to prevent transmission of disease.

Customs and behavior may differ from place to place, within the same geographical area, and will be influenced by ethnic, social and economic factors. Thus it is often difficult to generalize that the amount of disease occurring in a region or state is associated with characteristics of the general population of the state or region. In fact, such differences in prevalence of disease may be associated with particular characteristics of a particular group in the population. Sociologic and cultural factors are also difficult to separate from environmental factors, such as climate, which markedly influence people's behavior.

Because of the high prevalence of infection in Texas, the relatively low level of state resources allocated to the program (Appendix D), and attitudes conveyed to us in our hearings and in position papers we made two efforts to probe information and attitudes among Texas cattlemen more deeply. Dr. Mervin J. Yetley, Department of Rural Sociology at Texas A & M University carried out a special survey in which, a stratified sample of 150 Texas cattle owners were interviewed to assess their knowledge, attitudes, and sources of information regarding brucellosis. The entire report is given in Appendix C and is summarized here.

Five areas of brucellosis knowledge were investigated: (1) How the disease is contracted, (2) how it is spread, (3) its signs in cattle, (4) how the eradication program operates, and (5) its effect on human

beings. The survey was accomplished through personal interviews of a stratified random sample of beef producers and dairymen in three separate areas in the state, chosen to represent high, intermediate, and low prevalence areas. Useful interviews were obtained from a total of 100 beef producers and 50 dairymen.

This study demonstrated that producer knowledge over all of the several groups of questions asked about brucellosis is inadequate. However, producers had a high correct response rate to some questions on the most important aspects of the disease and the program. Beef producers and dairymen appear to be two distinct groups, especially in terms of level of knowledge and with respect to factors influencing their attitude toward the brucellosis program. Although dairymen possess better knowledge, on the average, than do beef producers, neither group has sufficient systematic total knowledge of brucellosis for wise decisions. No interpretable pattern of knowledge (correct answers) was found, suggesting that the information which producers are currently getting is incomplete, sometimes incorrect, and probably conflicting.

The local veterinarian is the most frequently used source of information on brucellosis, followed by friends and neighbors. Producers rated the local veterinarian as the most reliable information source. County extension agents, and the Texas Department of Health also ranked high on reliability. Except for the American Milk Producers, Inc., the various producer associations were not seen as highly reliable sources of information on brucellosis, nor were they frequently used as information sources.

The low level of knowledge base, combined with the nearly random pattern of knowledge, indicates that these information sources are not adequate for the task in either quality or quantity of information. Given the data, even the quality of information from the local veterinarians should be questioned, since they are the most frequently used source and viewed as the most reliable. Had their information been adquate in quality and quantity, producers' knowledge would be higher than was found in this study.

These data suggest that the image of federal government involvement should be minimized since producers seem sufficiently unenthused about government involvement to cause them to either discount information coming from government associated sources, or to avoid such sources entirely.

Level of income is a consistent predictor of knowledge. Hence, emphasizing the economic impact of brucellosis should be a motivation for producers to seek reliable information. In effect, this study suggests that where possible, government involvement should be replaced with greater individual responsibility and greater understanding of economic payoffs from prevention, augmented by other economic incen-

tives.

Further, it is important that information sources: (1) be qualified to give correct technical information on brucellosis, (2) be positive toward the brucellosis program, and (3) maintain credibility in the eyes of producers. It is difficult for the local veteriarian and extension agent to meet these criteria simultaneously. If they maintain an openly positive attitude toward the program, they may run some risk of losing their credibility with producers, who might then avoid them as information sources. The data on producers' knowledge indicates that these sources currently may lack adequate technical information, suggesting the need for a massive coordinated education program.

Fortuitously, Dr. J. E. Teague had recently completed a study, through mail questionnaires of a sample of owners of 700 herds selected from among the 2,700 herds of cattle officially under quarantine in Texas as of August 1977. His investigation has been reported in a thesis[1], which he graciously made available to the Commission. Owners of 336 of the herds responded by completing and returning the questionnaire. Owners of 364 herds did not return the questionnaire and were treated as non-respondents, without follow-up to determine if there were any differences between the two groups.

The questionnaire was more extensive than the one by Yetley, and provides additional information regarding respondents with experience of current or recent quarantine for brucellosis.

Teague's results support the results of Yetley's study regarding the need for improved communication with cattle owners and the inadequacy of knowledge of brucellosis among cattle owners. The replies also show that 63% of the respondents had doubts that the 1977 program to eradicate brucellosis could succeed. He also indicated that 16.4% of the respondents have had at least one case of undulant fever (human brucellosis) in their family. Teague's report provides replies that reinforce many of the comments received and observations made by the National Brucellosis Technical Commission.

Many studies throughout the U.S. have found that education and knowledge relate closely to personal health practices which are based on understanding how diseases are spread, and what should be done individually to avoid disease hazards. It has been found that "motivation" must also accompany knowledge to implement action by the individual to prevent, control or eliminate disease. The same is true with prevention, control and elimination of animal disease; knowledge is essential but not sufficient. Thus Yetley's work and observations of the Commission suggest that improved communication and greater knowledge must

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[1]Teague, J. E. (1978), The Economic Impact of the Disease Called Brucellosis on the Ranching and Dairy Industry of the State of Texas, Thesis presented to the Faculty of the University of Texas, Health Science Center, School of Public Health, Houston, Texas.

be accompanied by a system of rewards and penalties that are economically and socially important to cattle owners. These findings support the recommendations of the Commission for a new approach to brucellosis program Uniform Methods and Rules which provide more incentives for individual responsibility and accountability along with greater educational efforts for those with the most likely "need to know" (Section 6).

The finding that Texas cattle owners, who responded to the interviews or to questionnaires, were against government, particularly federal government involvement in the program reflects the views of a sizeable segment of cattle owners in many parts of the country, but appears to be particularly strong among the respondents in these studies in Texas. On the other hand many of these cattle owners want government to require calf vaccination, federal funds to pay for vaccination and federal funds to increase the amount of indemnity. These expressed views appear to have some inconsistencies. It has been suggested that this kind of anti-federal government feeling has been much less apparent in states where the state officials from Departments of Animal Health and Human Health took the leadership in initiating brucellosis programs with support from veterinarians, physicians, and cattle owners.[2] In those states, the brucellosis program was predominantly conducted by the state, for the economic benefit of the industry, with support from the federal government, and with ultimate benefit to human health. Under these circumstances, there were incentives for all concerned, and the program was not looked upon as a program of the federal government but rather a state program that was wanted by state officials, veterinarians, physicians and cattle owners. To help individuals and states again assume leadership, the Commission has recommended not only education and greater knowledge but also a system of rewards and penalties, both economic and social that would encourage participation of cattle owners, with assistance and leadership from state officials and practicing veterinarians.

In the past decade the role of the practicing veterinarian in the program has been diminished, and the role of state or federal employees has been increased. While this shift may have had a reasonable basis on economic and theoretical epidemiological grounds we believe it should be reconsidered, in light of recommendations for more individualization of programs for preventing and eliminating infection from herds. The status of the practicing veterinarian as a respected advisor to his client, should be recognized and used in facilitating program objectives.

In reviewing additional sociologic and cultural influences, one must consider the great expansion of the cattle industry in the Southern

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[2] A highly readable account of this type of interaction is presented in a 1967 M.S. research paper entitled The Wisconsin Brucellosis Campaign by Thomas P. Schomisch, University of Wisconsin, Department of Agricultural Journalism.

and Southeastern states in the past 20 years, based on the development of improved pastures. This expansion created a whole new group of owners who found it socially as well as economically rewarding to have a few cattle, while they had other full time employment. Since these part-time cattle owners do not depend on a successful efficient operation for their livelihood, they do not feel the need to know about good management practices and disease control. Yet they own up to 45% of the cattle in some Southern and Southeastern states. The large number of these relatively small beef herds, and the lack of knowledge and incentive of their owners for disease control, has hindered the detection of brucellosis in those areas. To fulfill the social function of meeting with other part-time cattle owners, these owners find that local sales and auction markets serve as social meetings. As part of attending these sales it is often socially and economically beneficial to sell or trade a few cattle. Thus, cattle in this area not only increased in number and density, but cattle movement also increased to provide an excellent means of spread of brucellosis through exposed and infected cattle. It has been said that "sales were social events" and that cattle moved as if they "were on wheels". Thus the technology of improved pastures and the influence of social patterns contributed greatly to the increase of brucellosis in these southeastern states.

Another factor, particularly among dairy herds, is the advancement of technology and the great increase in size of herds in the South and West. This has been accompanied by employment of workers who are not part of the family, and have no ownership incentive to improve conditions of husbandry, to prevent spread of disease. These large herds have also come to depend more and more on employees with different languages, different customs, and with less knowledge of sanitation and hygiene. Thus the changes in size of dairy herds, milk marketing systems and available labor supply have influenced the sociological and cultural characteristics, as well as personal rewards and incentives for workers on these farms. These appear to be contributing to a reduction in attention to health and productive efficiency of cattle in many of these dairies. (Section 4.3)

The Commission has attempted to consider sociological and cultural factors which influence prevention and control of brucellosis toward local eradication. Recommendations have been made to improve communications and knowledge, to develop an improved reward system, to emphasize individual responsibility not government responsibility and to put greater emphasis on flexibility to meet individual needs as affected by social and cultural factors.

Section 4.9 Economic Constraints on Policy Options

In addition to existing cultural, educational and social forces which may lead a relatively small group of producers to continue to live with brucellosis in opposition to the large number of producers who are striving for control leading to local eradication, there are also important (in some instances, almost overriding) economic forces influencing these choices. Programs which either ignore or run counter to these economic forces and which contain no provisions for compensation for economic losses incurred by producers or which fail to penalize producers for actions causing losses to others, run the risk of generating sufficient mechanisms of evasion, as well as social and political opposition, possibly to doom the program to failure.

The Economic Burden of Restrictions on Cattle Movement

The basic economic role of beef is to transform products which are either not edible, or cannot be economically harvested directly, by man into products that are not only edible, but highly palatable. In many parts of the country, the production of forage is heavily dependent on a highly variable rainfall. To efficiently utilize such forage, producers must be able to move cattle freely and quickly to take advantage of luxuriant feed in one area while at the same time avoiding the burden of drought in another. Moreover, producers who have maximum flexibility of animal movement can usually broaden the geographic and time dimensions of their market for either beef or dairy animals and thereby obtain higher prices. Hence, flexibility of cattle movement has economic value.

However, unrestrained movement of all cattle runs counter to effective control of all infectious diseases, including brucellosis. The U.M.&R. prohibit certain movements of female bovine animals from known infected herds. However, they do permit free movement from "herds not known to be infected", thus providing an incentive for avoiding brucellosis testing rather than, necessarily, maintaining disease-free herds. At least 28 states have imposed import restrictions which are more stringent than those specified in the U.M.&R. Moreover, a number of states have indicated that in the absence of any stringent federal control or eradication program, they will likely embargo cows and heifers from states that are under quarantine. If all states were to adopt similar stringent requirements, producers in quarantined states would be required to have two free tests before they could move their cattle anywhere except to slaughter or to quarantined feedlots.

Part of the conflict over freedom of movement is inherent in the characteristics of the disease and attempts to control its spread. However, changing conditions and new knowledge require regular, ongoing, objective review of restrictions of cattle movement to insure that all the restrictions are essential to the objective of control leading to

eradication, based on the best available epidemiologic information. While there might be arguments on their objectivity, the regular reviews of the U.M.&R. constitute such an ongoing review. Moreover, when such reviews demonstrate that restrictions on cattle movement are necessary, full compliance, with appropriate penalties for violations, should be expected by all parties. It must be recognized, however, that regulatory agenices have only a limited capacity to enforce regulations which may be perceived, for example, by sellers of livestock as running counter to their economic and personal interests.

An important economic benefit from local eradication of brucellosis is greater freedom of cattle movement and less regulatory intervention. These benefits are now enjoyed to a significant degree by producers in the "Certified Free" states and would accrue almost universally to producers, if local eradication were to be national in scope. Ironically, as is true for almost all technologically based improved productivity, in the final analysis the long-range "gainers" from brucellosis eradication will be consumers (in the form of lower cost beef and milk) and society generally (in reduced risk of exposure of human beings to brucellosis infection).

Differences Arising From On-site, Off-site Costs and Benefits

Even if all parties had complete understanding, controversy over the adoption of programs and practices designed to achieve brucellosis control leading toward eradication might still exist because not all of the benefits and/or costs associated therewith are immediately apparent to the individuals or groups making the crucial decision. Many such costs and/or benefits may be "off-site". That is, the benefits might not be captured by (or the costs not borne by) those making the decisions. For example, selling infected or exposed cattle for movement to another farm, county or state may impose heavy total costs on other producers. However, if none of these costs must be borne by the seller, he has little economic incentive not to make the sale.

The usual solution to conflicts arising from "off-site" costs or benefits is through compensatory payments to offset costs for practices which have limited "on-site" benefits but which have important "off-site" or societal benefits. By means of such payments, society may obtain the benefits from practices which would not be taken by individual operators acting independently. For example, farmers are compensated for making such land improvements as terracing and other water run-off control devices, because many of the benefits of such investments incur to people and communities living downstream, in the form of reduced dangers of flooding, siltation, and pollution.

Similarly, society may deem it economically advisable to compensate producers, at least in part, for their economic losses incurred in disposing of infected breeding and dairy animals, thereby enhancing control of the disease. The level of compensatory payments or indemnities should be high enough to serve as incentives to participate in

the program, but not so high as to serve as an incentive to perpetuate the disease.

Using the same rationale, an individual or firm may be assessed in the form of fines for "off-site" costs resulting from his actions which must be borne by others. In many instances, the market mechanism itself imposes the penalty. With brucellosis for example, infected or exposed cattle face movement restrictions which could have important market price implications.

For the most part, however, assessment for "off-site" costs which one individual or firm imposes on others are traditionally resolved through the courts and depend on our system of law. Thus, they require the damaged parties to establish both the cause and extent of the damage as a basis for compensation. This process for holding individuals or groups responsible for the full impact of damage resulting from their decisions and actions is often enhanced by enabling legislation and regulation. For example, there is federal case law under the implied warranty provisions of the Uniform Commercial Code which establishes liability for damages from sale of infected cattle which then infects other herds. However, claims under these provisions have been difficult to establish. State legislation requiring that anyone selling an infected breeding animal into a breeding herd would be liable for losses generated thereby, would reduce the burden of proof on the buyer and shift the responsibility on the seller from an implied to an explicit warranty (see Section 4.7). Such legislation likely would greatly reduce the spread of disease by "cattle traders" who deal in cattle of questionable origin and health status.

Conflicts Arising From Differences In Planning Horizons

The fact that individuals and groups have different planning horizons also acts as a constraint in their decision making to achieve effective control leading to brucellosis eradication. Each of us, when making rational analyses and decisions considers only those costs and benefits which accrue within the time period of our own planning horizon. A tenant farmer with a one-year lease, for example, tends not to make on-farm investments which will not pay for themselves in one year unless the landlord agrees to compensate him for the value of those investments remaining at the termination of the lease.

Similarly, a number of disease prevention practices are economically rational only if one's planning horizon is long enough to include the benefits of the program. For example, a producer likely would not vaccinate his heifer calves for brucellosis if he planned to sell his entire herd within a year and had no basis for expecting a higher price for vaccinated than for unvaccinated heifers. Nor would he vaccinate if he regularly sold his heifers to a trader who did not distinguish between vaccinated and unvaccinated heifers. A large number of small operators fall into this latter category.

Again, the conventional non-market procedure for handling this type of problem is through a system of compensation (for benefits) or assessment (for costs), as outlined above for off-site benefits and costs. In fact, conceptually the "planning horizon" problem can be seen as a subset of the "off-site" controversy. In this case, part of the costs or benefits fall outside the time dimension (as distinguished from the geographic and legal dimensions) of the decision maker.

We should not lose sight of the important role of the market place in resolving many of the conflicts outlined above. Moreover, the effectiveness of the market to encourage decisions which are epidemiologically sound improves as producers' perceptions of markets and prices improve. For example, throughout 1978, in most markets, vaccinated heifers have sold for a substantial premium over those not vaccinated even though many small producers selling to traders might not have been fully apprised of this premium. Similarly, vaccinated heifers consistently have access to many markets not available to those not vaccinated.

Issues Related to the Cattle Cycle

The cattle numbers cycle has been a pervasive force in the U.S. beef industry since this phenomenon first manifested itself a century ago. These cycles tend to last about ten years from low point to low point in cattle numbers. In between, there is a build-up phase of about six years wherein the level of cow culling is decreased sharply and more heifers are retained in the breeding herd. The build-up phase is followed immediately with a liquidation phase in which the cow herd is heavily culled and fewer heifers are retained. The relationship of this aspect of the cattle industry to the program is considered in greater detail in Section 4.2.

Coping With Uncertainties Associated With Brucellosis

Bovine brucellosis impacts most severely at the producer level--that is, on those relatively few beef and dairy producers whose animals become infected. In some instances these losses to individual producers may be greater than the firm can bear. Thus, beef and dairy herds at risk of infection create dangers to operators in terms of possibilities for abortion storms, constraints on herd development, loss of markets, and risk of human infection. This exposure to potential losses comprises a significant cost element of the disease. An important benefit of a control program leading to local eradication, therefore, would be a lowering of the probabilities of such losses.

Action programs such as vaccination, market testing and surveillance, herd testing and slaughter, restrictions on cattle movement, etc., are designed to reduce both the prevalence of the disease and its rate of spread. Individual producers formulate their own strategies for

coping with the risks and uncertainties associated with the disease within the framework of federal and state programs related to the disease and the limits of their own knowledge. However, some producers perceive the constraints and cost burdens of "the brucellosis program" to be greater than their direct losses from the disease. Such perceptions might be correct for some producers if the "off-site" costs in the form of the potential for spreading the disease are ignored. The likelihood for such perception might be high for producers with large herds in semi-arid parts of the country, where both the probability of initial infection and the rate of spread within the herd are low, and where costs of herd roundup for testing are high. In these cases, producer strategies occasionally have been directed more toward preventing the discovery of brucellosis in his herd than toward eliminating it. Under such circumstances, the net effect of government programs is likely to be counterproductive to the goals of either control, or control leading toward local eradication, unless conditions are recognized and dealt with through a combination of education designed to improve understanding of the disease, and through economic incentives in the form of either indemnities or penalties.

Benefit Cost Analysis

One of the primary charges to this Commission was to "make an economic benefit/cost analysis of the present national bovine brucellosis eradication program with its proposed extensions and any alternative programs which the Commission deems appropriate." The benefit/cost ratio is designed to estimate the dollars of added benefits which are expected per dollar of added expenditure associated with the particular program under consideration. These ratios for alternative programs of brucellosis control and/or eradication can then be compared with one another and with ratios for expenditures in other investment opportunities to help in establishing priorities among policy alternatives.

Two basic techniques are available for aggregating the economic data which determine the benefit/cost ratio--the partial budgeting technique and systems simulation. With partial budgeting attempts are made to identify and estimate the added benefits and costs to be accrued within a defined population as a consequence of specified alternative actions. This technique has serious limitations as an analytical system for policy issues and was not used. Instead, a systems simulation model was used in making benefit/cost analysis.

Systems simulation attempts to more adequately model a simplified version of the real world in order to better assess the impact of alternative actions on the total system. In so doing, it makes a very important contribution to the analysis of difficult problems involving the economic implications of complex interactions of both biologic and engineering systems. As a caveat, however, it should be stressed that all systems simulation models must, of necessity, make simplifying assumptions, and represent abstract versions of the real world. There remains a very large gap between the theoretical manipulations of disease models and the application of models to specific diseases, especially on a large scale. They should not, therefore be the only basis upon which policy decisions are based.

The base model developed was patterned, in part, after the model developed by APHIS, USDA in 1977, but was modified in several important ways:

1. The states were divided into eight regions (compared to five for the APHIS model), grouped on the basis of their similarity with respect to several criteria relating to brucellosis, such as level of infection, herd size distribution, methods of operation, trading patterns, and effectiveness of brucellosis surveillance and control.

2. The computer sequence and procedures were modified significantly from those of the APHIS model.

3. Many of the epidemiologic coefficients and assumptions differed significantly from those used in the APHIS model. For a detailed description of the simulation model, the data inputs and procedures for estimating those inputs, see Annex 1 of Appendix B.

Determining the appropriate physical loss coefficients associated with varying levels of alternative program inputs by regions, herd size, year of infection, etc., is, in the final analysis, a limiting factor in a simulation model of a complex disease such as brucellosis. Unfortunately, the Commission had neither the time nor resources to develop field studies to accompany the model. More importantly, program data as presently reported by states, and compiled by APHIS staff, are inadequate as a basis on which to project physical losses under alternative programs. Hence, although the Commission was unable to completely restructure the field data, an extensive sampling of program data from one or more states in each of the regions was undertaken. By questionnaire and direct telephone contact with each of the regional epidemiologists, several station epidemiologists, state veterinarians, or state program supervisors, significant items were collected. These include:

1. Within herd infection rates on initial herd test and cumulative rates over the duration of the quarantine period. The data were collected according to herd size and percentage vaccination within the herd. Infection rates for vaccinated and unvaccinated animals within the herds were calculated.

2. Data on length of time between initial test and release from quarantine and total number of herd tests required, by herd size and amount of vaccination, were assembled for derivation of coefficients on vaccine effect and clean up rates.

3. Results of epidemiologic traces in each of the regions to determine relative importance of several modes of new introductions into previously free herds such as neighborhood spread, adjacent herd contact or fence spread, and purchase. In addition, extensive data were assembled on apparent residual infection, following release from quarantine.

4. Cross comparisons were made between APHIS staff calculations on MCI identification tracebacks and testing, and data from the local source.

5. Cross comparisons were made between local and APHIS compiled reported data on calfhood vaccination rates and the amount of herd infection not disclosed in a timely manner by surveillance.

In addition, the in-depth program analysis of 12 states given in detail in Appendix D, and the survey of all 50 state veterinarians in

Appendix E furnished important data for derivation of model coefficients.

As a part of the information gathering process, a detailed questionnaire relating to operations, management practices and costs was mailed to a random sample of beef and dairy producers in selected states representing each of the eight regions of the United States. In all, completed questionnaires were returned by 1211 beef operators and 1367 dairy operators. Information from these questionnaires was useful in identifying differences in management practices and geographic sources of breeding stock purchases, and in assessing producer costs associated with several brucellosis-related management practices.

Program Alternatives Modeled

The following brucellosis programs were modeled:

Program Index	Program Alternatives
1	Base model year 1975-76 The base model was designed to simulate conditions prevailing in 1975-76 (the year prior to the formation of the Commission and the first year of the Commission's activity). Included in this model are the 1975-76 levels of vaccination, surveillance, levels of infection, levels of management and prevailing Uniform Methods and Rules. Within this model, brucellosis infection was assumed to be essentially stabilized at the 1975-76 level, in aggregate. Each of the other programs alternatives was designed to represent a single modification from this base program. In this way, the impact of the particular control practice stressed in the program is measured from a base program which was specifically designed to perpetuate infection at the 1975-76 level.
2	Base Model plus accelerated programs This model was designed to simulate conditions which might prevail under the APHIS "10-Year Accelerated Eradication Program." During the period of time since 1976 in which this Commission has been conducting its study, the States of Tennessee, Georgia, Alabama and Arkansas have entered into this accelerated program. During the period when, and in those regions where, area testing and first point of concentration

(FPC) testing is scheduled to take place, program efficiency (the level of infection detection and elimination) is assumed to increase sharply; hence, the level of infection is materially reduced during this period. However, what happens to program efficiency or quality control after area testing is completed and FPC discontinued is crucial to the final outcome. Two alternatives were modeled. In the first (called accelerated program 1) program quality was assumed to remain at the high level reached during area testing and FPC. In the second program (called acclerated program 2) efficiency was projected to drop back to the level which prevailed in the region prior to area testing.

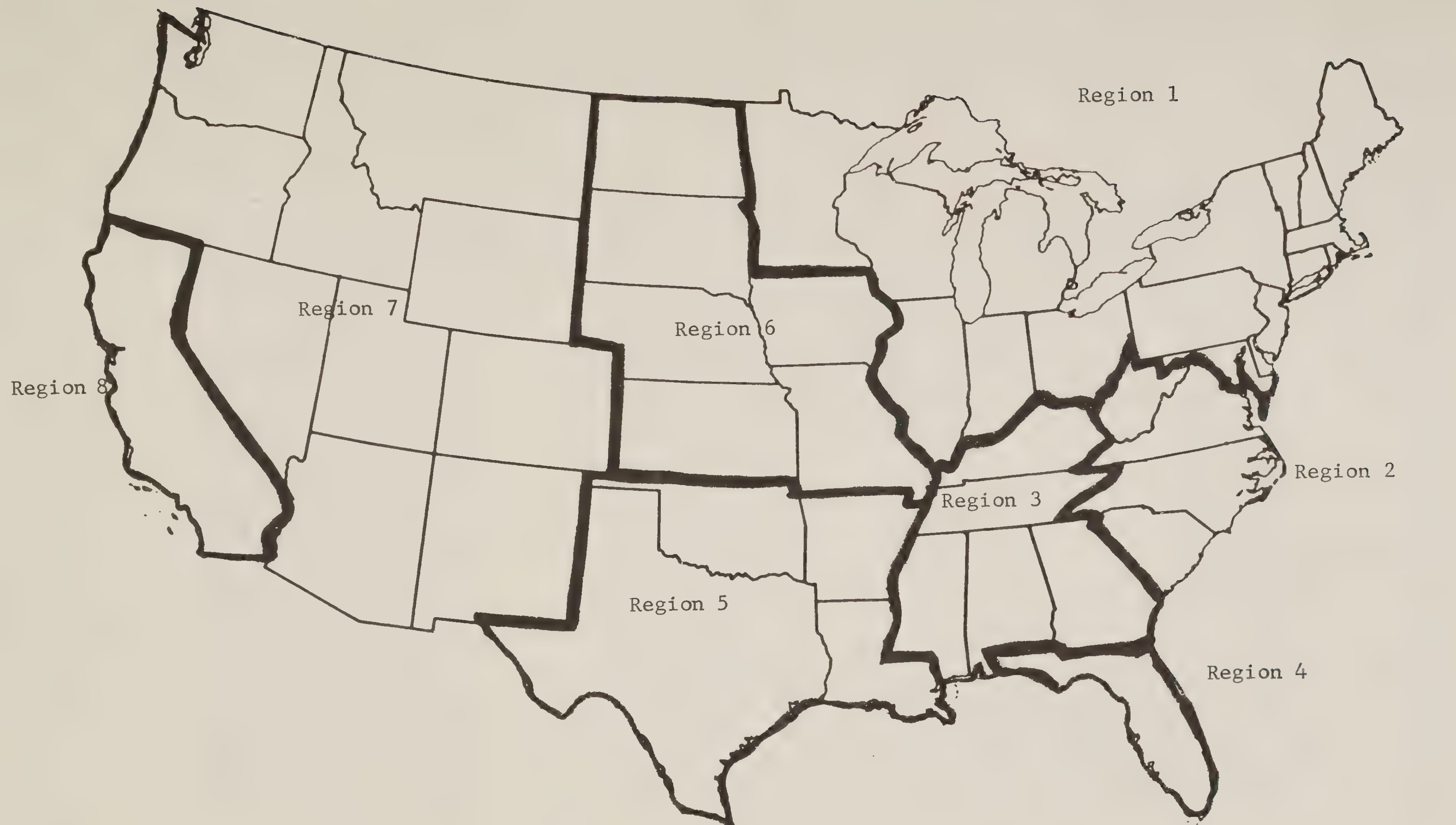
3 Base model plus calfhood vaccination

This model assumes that incentives will be established for increasing calfhood vaccination in Region 3, 4, 5, 6, and 7. It is assumed that Regions 1, 2, and 8 are already proceeding to bring the disease under control leading to local eradication within those regions. Included in the program would be a requirement in all regions for vaccinating females sold for breeding purposes shipped across state lines (comparable to California import requirements and the North Dakota law). The model tests this program at three levels of herd vaccination; 90 percent or higher, 60-89 percent, and 20-59 percent. It is assumed that these levels of vaccination were imposed on the base program (Number 1, above).

4 Base model plus whole herd vaccination

This model is designed for use in areas of high prevalence (Regions 3, 4, and 5); the base program is to apply in all other areas. This program assumes that promising research in progress will demonstrate that adult cattle may be vaccinated successfully with reduced dosages and that distinction can be made between field strain and strain 19 titers. High level herd protection by vaccination could thus be achieved much more rapidly by vaccinating whole herds than with calfhood vaccination. Vaccination could occur under two plans: (1) Herds known to be infected and (2) High risk, non-infected herds--that is, there are no reactors revealed by complete herd test at

DEMARKATION OF REGIONS FOR MODEL



Puerto Rico, V.I., Alaska and Hawaii not included

the time of vaccination and the herd has not been under quarantine during the past 6 months (see pages 6-12 - 6-14).

Infected herds

For "infected herds," or herds of unknown status at high risk of infection, the entire herd would be tested and reactors would be branded and slaughtered. The test-negative animals 10 months of age and over would be vaccinated with a reduced dose of vaccine (ca 5×10^9 cells) subcutaneously and receive the AV brand as in the current guidelines. The herd would remain under quarantine. Testing should be resumed not later than 6 months post vaccination and reactors to the rivanol or CF at 1:20 would be slaughtered. Quarantine would be lifted after two consecutive negative whole herd tests 6 and 12 months after the first negative herd test. Test-negative would be on the basis of negative rivanol or, CF $<$ 1:20. AV branded animals negative on these tests may move or be sold thereafter subject to similar test requirements as applies to all other similar types of cattle.

High risk, noninfected herds (see pages 6-14, 6-19)

For noninfected qualified herds at high risk, the entire herd must test negative, animals would be vaccinated as above and identified with a new official AV tattoo and individual identification. Animals could be moved or sold on the basis of a negative test 3-6 months after vaccination of test eligible animals (those over 12 months of age).

5 No program

Although highly unlikely that support for brucellosis programs will be cancelled, a "No Program" scenario was developed in order to determine the effects of such a situation upon the economy. "No federal program support" suggests that all surveillance systems would be cancelled and federal support presently existing for laboratory facilities, testing equipment and facilities, field tests, indemnities, financial aid to state pro grams, etc., would be curtailed. Although many states likely would provide services to protect

against the spread of the disease, the scenario assumes no state programs, as well. The physical losses projected for this program option were taken, largely, from the "No Program-No Vaccination" Option of the APHIS, USDA model.

Estimating Benefits

We identify as benefits from investment in bovine brucellosis control, the avoidance or reduction in losses caused by the infection. These losses fall into three categories: (1) economic losses from brucellosis infection of people; (2) economic losses generated by livestock movement constraints and, (3) physical reductions in meat and milk production due to the disease. Although the first two of this set of losses are likely to be very substantial, neither of them can be quantified in dollar terms with a sufficient degree of confidence to be included in an estimate of economic benefits. Hence, our benefit/cost analysis report (Appendix B) describes the nature of these losses, and confirms that they occur in the real world. However, such costs were not included in our benefit/cost analysis. Instead, we focus on estimating reductions in physical losses as a basis for estimating economic benefits for the various program alternatives. Economic losses generated by livestock movement constraints are not borne equally by all producers in all regions. They accrue most heavily to those with infected herds or in the high prevalence areas. Thus, those who are in the certified free states, or who have certified free herds, have few movement constraints and therefore have increased economic benefits. These are not quantified and are not included in the benefit/cost analysis.

Physical Production Losses

Production losses of meat and milk stem basically from damage to uterine and mammary tissue caused by *Brucella abortus* infection. The component sources of production losses were identified as follows: (1) From dairy and beef calf loss due to abortion, including losses of calves born so weak that they die within several days; (2) From infection resulting in calves which are weak but which live. Most of these calves live to perform some economic function but do not compensate for their weight loss; (3) From milk losses due to specific pathologic effects to mammary tissue; (4) From effects of infection on reproductive efficiency; and (5) From loss of genetic potential for production due to increased involuntary culling.

Estimates of physical losses are based upon coefficients prepared by members of the Commission after (1) a review of literature reporting studies of the impacts of brucellosis on physical production of cattle; (2) an extensive sampling and analysis of program data from one or more

states in each of the eight regions; (3) information and judgements supplied by regional epidemiologists, state epidemiologists, state veterinarians, state program supervisors, and experienced ranchers and dairymen in response to questionnaires and numerous correspondence and telephone calls. For a detailed listing of the physical loss coefficients, a description of the procedures by which they were calculated and the assumptions on which they were based, the reader is referred to Chapters III and IV of Appendix B. The annual beef losses for the several alternatives is presented in Table 5.1. Tables 5.2 and 5.3 present similar data for dairy calf losses and milk losses respectively. The absence of an estimate of loss for year 0 in the "No Program" option does not signify there were no losses. In using the APHIS loss projections one year's lag was required to bring their assumed starting level of infection up to the level prevailing in 1976.

Economic Benefits Associated With Program Alternatives

In estimating economic benefits for alternative programs, differences in annual physical losses associated with each program alternative were measured from levels of losses projected for the base program. These annual differences in losses were then used to represent changes in the total supply of beef and milk in calculating new equilibrium prices, using a modification of the USDA "Cross-Class-Commodity Feed-Grain-Livestock-Wheat Model". Economic benefits were then calculated in terms of consumers and producers surpluses. The logic of consumers and producers surpluses is illustrated and briefly explained in Chapter IV of Appendix B. These estimates of economic benefits are used later in computing the benefit/cost ratios.

Estimating Program Costs

For purposes of benefit/cost analysis, costs were identified as (1) expenditures incurred by state and federal governments relating to brucellosis, plus (2) Costs incurred by beef and dairy producers due to brucellosis.

State and Federal Expenditures

Base figures used in projecting federal expenditures came from projections made by APHIS, USDA for their 10-year Accelerated Eradication program. Modifications of these costs were made to account for differences in program indices and levels of infection from those assumed in the APHIS projection. An outline of the relevant cost components is presented in Chapter V of Appendix B. A summary of the projected federal expenditures by program alternative is listed in Table 5.12.

Under the cooperative state-federal brucellosis program, states are required to fund not less than 40 percent of the joint state-federal costs. However, in identifying state contributions, states are per-

mitted to include all identified producer costs. Considerable variation exists among states in accounting procedures as well as in determining which producer costs are included as a part of reported state costs. Moreover, variation exists within some states from year to year in determining which producer costs are included. To systematize estimating procedures and still attempt to avoid either omissions or duplications of costs, the following simplifying assumptions were made in estimating state costs:

(1) All producer costs for vaccine and for veterinary expenses associated with vaccination or testing was included under state expenditures;

(2) The minimum base estimate for total state expenditures is 66.7 percent of federal expenses that year.

A summary of annual state expenditures is presented by program alternative in Table 5.13.

Producer Costs

Producer costs associated with state-federal programs which are not included in projections of state expenditures include added cost for labor, machinery, fuel, etc. for extra assembling and working cattle in connection with vaccinations and testing. Since data on the magnitude of these costs were not otherwise available, questions were included in the survey questionnaire mailed to a random sample of producers in selected states representing the eight regions. A summary of the costs derived from this survey, and a detailed explanation of the procedures used in projecting producer costs for both cattlemen and dairymen are given in Chapter V of Appendix B. A summary of producer costs by program alternative is listed in Table 5.14 and total program costs are summarized in Table 5.15.

Benefit/Cost Ratios

We are now in position to make an economic evaluation of the program alternatives under consideration.

Three alternative economic criteria are used in comparing alternative policies or programs:

(1) Benefit/cost ratios, which are calculated by dividing the present value of the projected change in benefits over the relevant planning horizon (20 years in our model) by the present value of the projected change in costs;

(2) The Net Present Value, which is calculated by subtracting the present value of the projected change in costs from the present value of the projected change in benefits; and

(3) The Internal Rate of Return (I.R.R.), which is defined as the rate of discount, which will make the present values of the projected stream of benefits just equal to the present value of the projected stream of costs.

The present value and I.R.R. criteria will always give the same economic ranking of alternatives. However, it is quite possible to obtain a different economic rating if benefit/cost ratios are used. This is particularly true when changes in costs from the base program may be small or even negative, as is the case in this analysis, as we shall see. As a consequence, the benefit/cost ratio is an inferior criterion for making economic evaluations of alternative policies. However, because the Commission has been charged with making a benefit/cost analysis, we have used two measures: the benefit/cost ratio and the net present value.

The following procedure was used in making the economic evaluation.

First, both annual benefits and annual costs were converted from "1976" dollars to "current year" dollars using an assumed 5 percent annual rate of inflation.

Second, to place the benefits and costs on a common time pattern, the projected annual data were converted to present value using a 9.0 percent discount rate. The accumulated present value of projected changes in benefits for each program alternative, relative to the base program, is listed by program alternative in column 1 of Table 5.16, while the present values of accumulated costs are shown in column 2.

Third, the program cost for the base program was entered in column 3 of Table 5.16. This figure was then subtracted from column 2 to get marginal program cost for each alternative, which is listed in column 4.

Fourth, the marginal benefit/cost ratio was calculated by dividing the change in benefits by changes in costs. (Column 1 ÷ column 4). The marginal benefit/cost ratio is presented in column 5. The net present value of each alternative (column 1 minus column 4) is shown in column 6 under the heading "net benefits".

Table 5.17 lists the order ranking of the several program alternatives according to four criteria: (1) the present value of the change in benefits (column 1), (2) the present value of program costs (column 2), (3) the benefit/cost ratio (column 3) and (4) the net present value (column 4). A comparison of these separate rankings provides an insight into the contributions which each of these program alternatives might make toward a total program of control leading toward local eradication, although only the latter two criteria are considered, by themselves, to provide a ranking useful for policy considerations. Keep in mind throughout this discussion that each comparison represents the movement

from the base program to the particular program alternatives being compared.

From these calculations, and within the limits of ability of the model to simulate outcomes, several generalizations can be made:

Vaccination (both calfhood and "whole-herd") superimposed on the base program in the selected regions, was found to be effective in reducing physical losses. Moreover, the level of herd vaccination is strongly and positively related to economic benefits. In this analysis, calfhood vaccination generated more benefits than did whole-herd vaccination. This is true however because, in the model, whole herd vaccination was applied, in addition to the base program, only in the three high prevalence regions, while calfhood vaccination was applied in all regions except 1, 2 and 8. It must be understood that in region 8, and in some states in region 1, present vaccination levels are already at or higher than the medium level. Furthermore in regions, 1, 2 and 8 prevalence is already low, so it would be inappropriate to generalize the extent to which benefits would be increased still further by extending these vaccination levels to all regions.

When ranked according to program costs, with the lowest cost alternative ranked first, the order is somewhat reversed from the previous ranking, with the "no program" alternative well out in front, having zero costs. High-level calfhood vaccination, on the other hand, ranked lowest. An important deterrent to high-level vaccination, of course, is the high level of program costs which continue indefinitely into the future. The calfhood vaccination options ranked below the corresponding level of whole-herd vaccination because of the greater area covered by calfhood vaccination.

In terms of the benefit/cost ratios, the whole herd vaccination alternatives ranked highest, with the medium-level option first and the low-level and high-level following somewhat behind but close together. The low-level and medium-level calfhood vaccination options came in fourth and fifth, respectively, followed in order by the accelerated program and accelerated program 2. The high-level calfhood vaccination, which ranked first in terms of total benefits, ranked 8th in terms of the benefit/cost ratio.

In terms of net benefits, the order again changed just a little. The only significant change, however, was that the high-level calfhood vaccination option moved up from 8th to 5th, while low-level calfhood vaccination dropped from 4th to 6th. These changes point out a weakness of the benefit/cost ratio. When marginal costs are low, a very modest adjustment in either costs or benefits can change the benefit/cost ratio substantially.

Again, it should be pointed out that it is inappropriate to generalize the value of the added program variable "whole herd vaccination"

which was modeled in three high prevalence regions to the entire country. We specifically did not model this alternative in all regions, first, because it would be of questionable epidemiologic value broadly applied in the low prevalence regions, and secondly, because it would be extremely costly.

The very favorable ranking of the whole-herd vaccination options, combining, as they did, herd testing, holds considerable promise of an approach that could materially reduce the level of herd infection in the high prevalence regions, once this practice has been approved and adopted. However, the medium level of herd vaccination (60-89 percent) for any region is higher than can reasonably be expected based on historical performance records and current producer attitudes.

The results of this computer simulation strongly support the proposition made in Section 6, that losses can be greatly reduced by a combined strategy of judicious selection of herds in the high prevalence areas for whole herd vaccination, combined with elimination of reactors on the basis of improved application of diagnostic criteria. It seems likely that both program and producer costs can be minimized, while herds and areas progress toward local eradication, if selection of both the infected and noninfected herds at high risk is focused on those where epidemiologic evaluation indicates greatest potential of spread of infection because of geographic proximity or trading patterns.

Although the difference in net benefits and benefit/cost ratios between accelerated programs 1 and 2 appear to be relatively small, they merit comment. Recall that the basic difference between these two options was that in option 1 the high level of program performance achieved during the period when area testing and first point of concentration (FPC) testing were taking place was assumed to be maintained indefinitely into the future. In option 2, on the other hand, program performance was assumed to drop back within two years after FPC ceased, to nearly the level which prevailed in the region prior to when area testing began. The higher performance level in the first option is manifest in a flow of benefits with a present value which is approximately $80 million higher than for option 2. At the same time, the present value of the two cost streams differ very little. However, more of the costs under option 1 represent educational and training programs designed to maintain a high level of program participation and performance. In option 2, more of the costs were attributable to the higher levels of infection.

It might be insightful to look at the consumer and producer sectors using consumer surpluses and producer surpluses separately. This information is shown in Table 5.18. These data clearly show which sectors lose and which gain from brucellosis control programs. In general, those programs which reduce infection and thereby increase supplies of beef and milk, lead to lower commodity prices which benefit

consumers. Consider, for example, which groups gain or lose the most by shifting from the base program to a high level of whole-herd vaccination. This analysis indicates that consumers would be made better off by over $2.0 billion over the 20-year program, representing a return of more than $14 on every dollar invested. However, producers would be made worse off by more than $1.2 billion over this same period, representing a loss of more than $8 to producers for every dollar invested in the program.

On the other hand, the benefit/cost ratio to producers is very high under the no program option owing to the high beef and milk prices that result from the heavy physical losses with no program. Clearly, those producers who can escape the ravages of this disease stand to gain the most in the absence of any government programs. But under this option in the model, national infection rates would rise in the 19th year to approximately 45% of dairy herds and 70% of beef herds, so individual producers would have to make substantial efforts to maintain their herds free of infection. They would also have to deal with the uncertainty imposed by the threat of infection. Those producers who could not maintain herds free from infection would be hard pressed to compete. At the same time, in the absence of any government program, the losses in product would be translated into substantial costs to the consumer. The high negative benefit/cost ratio suggests that for every dollar saved by the elimination of even the base program (which merely maintained infection at the prevailing level) would result in a loss to consumers of about $26.00.

Remember that this analysis did not include the economic benefits associated with improved human health attributable to lower levels of bovine brucellosis infection. Nor did it give consideration to reduced pain and suffering associated therewith. Furthermore, for want of data on which to base estimates, economic benefits accruing to producers from greater freedom of movement of livestock associated with diminished levels of infection were also ignored. An important benefit to individual producers from control programs leading to local eradication of brucellosis would be the reduction and final elimination of these important risks.

The reader should again be cautioned that this analysis was based on estimates of both herd infection levels and physical losses requiring judgements on matters where data and knowledge were limited. Although the Commission went to great length to gather information from all known sources, and tried to be as realistic as possible in making estimates, the final benefit/cost ratios and net benefits could, in the real world, vary somewhat from those presented. However, the analysis indicates that errors within a range of plus or minus 50 percent would not alter the conclusions that positive economic returns can be expected from dollars invested to move from the base program by the addition of any one of the activities comprising the brucellosis

program alternatives considered in this study. Moreover, the fact that the "no program" alternative ranked so dramatically low in terms of both the benefit/cost ratio and net benefits, leaves no question about the positive economic benefits of the cooperative state-federal program - even as it existed in 1975-76, when compared to having no program.

Table 5.1 Projected Weaner Beef Calf Losses, by Program and Year

	Program									
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination			
Year	Base	1	2	Low	Medium	High	Low	Medium	High	No Program
	Thousand Pounds									
0	80,254	80,254	80,254	80,254	80,254	80,254	80,254	80,254	80,254	-----
1	65,358	66,324	66,324	60,615	60,615	60,615	65,358	65,358	65,358	97,983
2	64,184	63,076	63,076	41,891	39,736	39,736	64,184	64,184	64,184	163,093
3	66,649	63,805	63,805	31,033	21,822	20,796	37,612	37,612	37,612	264,657
4	67,036	67,170	67,170	28,969	16,641	12,382	36,945	22,707	22,707	408,222
5	74,083	61,267	61,267	32,010	17,316	11,138	40,160	14,701	14,701	568,264
6	75,523	52,164	52,164	30,697	16,937	10,787	37,658	15,566	9,663	733,534
7	81,769	47,149	47,149	32,625	17,689	11,282	39,496	16,132	6,596	884,896
8	91,960	43,811	43,811	36,734	19,054	12,277	44,210	17,228	7,319	1,014,201
9	88,958	37,074	37,074	33,616	18,363	11,678	40,064	16,510	6,884	1,119,546
10	79,884	29,262	28,885	29,335	15,902	9,803	34,729	13,626	6,102	1,202,059
11	79,755	26,005	25,538	27,503	15,344	9,384	32,205	12,908	5,761	1,264,746
12	81,184	23,828	26,907	27,143	15,112	9,435	31,852	12,992	5,753	1,311,205
13	82,941	21,661	28,528	26,213	14,955	9,496	30,562	13,310	5,638	1,344,600
14	75,664	17,511	26,662	23,526	13,736	8,255	27,420	11,236	5,200	1,369,255
15	76,597	15,800	27,465	22,715	13,386	8,073	26,381	10,965	5,052	1,385,128
16	77,398	14,325	28,137	21,619	13,057	7,981	25,030	10,721	4,931	1,397,029
17	74,439	12,242	27,373	20,220	12,377	7,435	23,456	10,229	4,716	1,406,075
18	74,791	10,865	27,758	19,560	12,608	7,560	22,713	10,468	4,760	1,411,329
19	66,374	8,459	24,827	16,797	10,077	8,423	19,519	8,778	4,182	1,415,500

Table 5.2 Projected Dairy Calf Losses, by Program and Year

	Program									
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination			
Year	Base	1	2	Low	Medium	High	Low	Medium	High	No Program
	Thousand Pounds									
0	404	404	404	404	404	404	404	404	404	-----
1	364	364	364	327	327	327	364	364	364	2,412
2	300	298	298	228	215	215	300	300	300	5,011
3	279	274	274	168	138	132	185	185	185	10,805
4	270	261	261	143	103	92	159	119	119	18,029
5	270	250	250	127	87	73	139	76	76	24,380
6	275	240	240	120	78	64	128	64	56	29,441
7	284	229	229	117	74	60	126	58	47	32,962
8	298	218	218	117	73	58	125	55	44	35,480
9	307	203	203	115	71	56	123	54	42	37,742
10	307	184	184	112	68	53	119	52	40	40,197
11	305	166	166	107	65	51	114	50	38	43,381
12	304	150	134	103	63	49	110	49	37	46,494
13	304	137	145	100	62	48	107	48	36	50,439
14	300	125	139	97	60	46	103	46	35	54,852
15	297	114	135	93	58	45	99	45	35	59,654
16	294	104	132	90	56	44	96	44	36	64,661
17	291	95	129	86	55	43	92	43	33	69,701
18	286	87	127	83	53	42	89	42	33	74,571
19	277	79	123	79	51	40	84	41	32	79,034

Table 5.3 Projected Dairy Milk Losses, by Program and Year

	Program									
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination			
Year	Base	1	2	Low	Medium	High	Low	Medium	High	No Program
	Thousand Pounds									
0	38,056	38,058	38,058	38,058	38,058	38,058	38,058	38,058	38,058	-----
1	35,278	35,278	35,278	32,186	32,186	32,186	35,278	35,278	35,278	76,274
2	28,753	28,621	28,621	22,645	21,474	21,474	28,753	28,753	28,753	158,149
3	26,774	26,347	26,347	16,884	14,263	13,824	18,292	18,292	18,292	349,617
4	26,029	25,205	25,205	14,661	11,066	10,017	16,034	12,322	12,322	605,162
5	25,960	24,290	24,290	13,181	9,340	8,187	14,184	8,450	8,450	860,092
6	26,427	23,397	23,397	12,449	8,714	7,456	13,199	7,352	6,597	1,077,382
7	27,310	22,439	22,439	12,203	8,343	7,014	12,883	6,748	5,720	1,258,484
8	28,546	22,446	22,446	12,211	8,204	6,824	12,878	6,506	5,465	1,404,445
9	29,427	20,118	20,118	12,115	8,052	6,650	12,781	6,373	5,273	1,532,389
10	29,499	18,405	18,405	11,767	7,783	6,401	12,418	6,187	5,081	1,657,950
11	29,277	16,703	16,703	11,345	7,508	6.162	11,967	6,008	4,919	1,808,228
12	29,183	15,275	15,545	11,000	7,295	5,891	11,604	5,879	4,803	1,943,289
13	29,189	14,075	14,768	10,705	7,123	5,836	11,291	5,777	4,713	2,114,037
14	28,907	12,916	14,172	10,354	6,931	5,879	10,920	5,655	4,620	2,305,429
15	28,566	11,857	13,744	10,008	6,753	5,537	10,550	5,539	4,540	2,515,078
16	28,317	10,838	13,464	9,696	6,602	5,422	10,212	5,444	4,475	2,738,659
17	28,016	10,112	13,233	9,389	6,458	5,315	9,883	5,356	4,419	2,969,767
18	27,622	9,356	13,015	9,085	6,016	5,213	9,563	5,273	4,368	3,199,868
19	26,804	8,595	12,662	8,711	6,122	5,089	9,167	5,157	4,304	3,419,361

Table 5.12. Projected Federal Costs, by Program and Year (1976 Dollars)

	Program								
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination		
Year	Base	1	2	Low	Medium	High	Low	Medium	High
	Thousand dollars								
0	36,834	36,834	36,834	36,834	36,834	36,834	36,834	36,834	36,834
1	36,834	42,889	42,889	45,100	45,100	45,100	39,517	41,894	43,626
2	36,834	53,979	53,979	50,571	58,837	58,837	39,517	41,894	43,626
3	36,834	74,149	74,149	39,733	53,470	61,736	39,517	41,894	43,626
4	36,834	93,789	93,789	37,992	40,890	54,628	39,517	41,894	43,626
5	36,834	97,453	97,453	37,992	39,149	42,048	39,517	41,894	43,626
6	36,834	93,200	93,200	37,992	39,149	40,307	39,517	41,894	43,626
7	36,834	91,400	91,400	37,992	39,149	40,307	39,517	41,894	43,626
8	36,834	77,800	77,800	37,992	39,149	40,307	39,517	41,894	43,626
9	36,834	66,300	66,300	37,992	39,149	40,307	39,517	41,894	43,626
10	36,834	56,600	54,100	37,992	39,149	40,307	39,517	41,894	43,626
11	36,834	45,200	42,700	37,992	39,149	40,307	39,517	41,894	43,626
12	36,834	37,000	34,500	37,992	39,149	40,307	39,517	41,894	43,626
13	36,834	32,400	29,900	37,992	39,149	40,307	39,517	41,894	43,626
14	36,834	30,600	28,100	37,992	39,149	40,307	39,517	41,894	43,626
15	36,834	29,000	26,500	37,992	39,149	40,307	39,517	41,894	43,626
16	36,834	28,000	25,500	37,992	39,149	40,307	39,517	41,894	43,626
17	36,834	27,000	24,500	37,992	39,149	40,306	39,517	41,894	43,626
18	36,834	26,500	24,000	37,992	39,149	40,307	39,517	41,894	43,626
19	36,834	26,000	23,500	37,992	39,149	40,307	39,517	41,894	43,626

Table 5.13. Projected State Costs, by Program and Year (1976 Dollars)

		Program							
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination		
Year	Base	1	2	Low	Medium	High	Low	Medium	High
	Thousand dollars								
0	24,568	24,568	24,568	24,568	24,568	24,568	24,568	24,568	24,568
1	24,568	28,607	28,607	30,849	30,849	30,849	32,952	40,381	45,794
2	24,568	36,004	36,004	33,915	42,254	42,254	32,952	40,381	45,794
3	24,568	49,457	49,457	29,294	40,700	46,980	32,952	40,381	45,794
4	24,568	62,557	62,557	28,185	32,912	44,316	32,952	40,381	45,794
5	24,568	65,001	65,001	28,185	31,803	36,529	32,952	40,381	45,794
6	24,568	62,164	62,164	28,185	31,803	35,420	32,952	40,381	45,794
7	24,568	60,964	60,963	28,185	31,803	35,420	32,952	40,381	45,794
8	24,568	51,893	51,893	28,185	31,803	35,420	32,952	40,381	45,794
9	24,568	44,222	44,222	28,185	31,803	35,420	32,952	40,381	45,794
10	24,568	37,752	36,085	28,185	31,803	35,420	32,952	40,381	45,794
11	24,568	30,148	28,481	28,185	31,803	35,420	32,952	40,381	45,794
12	24,568	24,679	23,012	28,185	31,803	35,420	32,952	40,381	45,794
13	24,568	21,611	19,943	28,185	31,803	35,420	32,952	40,381	45,794
14	24,568	20,410	18,743	28,185	31,803	35,420	32,952	40,381	45,794
15	24,568	19,343	17,676	28,185	31,803	35,420	32,952	40,381	45,794
16	24,568	18,676	17,009	28,185	31,803	35,420	32,952	40,381	45,794
17	24,568	18,009	16,342	28,185	31,803	35,420	32,952	40,381	45,794
18	24,568	17,676	16,008	28,185	31,803	35,420	32,952	40,381	45,794
19	24,568	17,342	15,675	28,185	31,803	35,420	32,952	40,381	45,794

Table 5.14. Projected Producer Costs, by Program and Year (1976 Dollars)

		Program							
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination		
Year	Base	1	2	Low	Medium	High	Low	Medium	High
	Thousand dollars								
0	29,539	29,539	29,539	29,539	29,539	29,539	29,539	29,539	29,539
1	31,912	34,025	34,025	36,135	36,135	36,135	50,026	60,417	70,174
2	33,908	35,294	35,294	41,045	47,486	49,245	49,021	62,413	72,170
3	35,498	36,227	35,954	28,437	36,603	42,250	43,736	57,128	66,884
4	35,023	49,627	40,627	24,714	26,620	33,761	40,963	50,133	59,889
5	39,455	38,000	38,000	28,030	27,033	28,739	44,322	44,174	53,931
6	38,827	32,888	32,888	26,021	26,391	27,838	41,336	44,798	50,951
7	42,115	27,683	27,683	27,476	27,162	28,407	42,668	45,542	46,222
8	49,049	25,697	25,697	31,783	29,022	30,226	47,847	49,096	48,002
9	48,810	21,962	21,962	30,113	28,907	30,020	45,385	48,669	48,493
10	43,174	17,218	16,869	26,568	26,606	28,167	49,830	44,211	46,428
11	42,945	15,164	13,995	25,140	26,084	27,562	38,797	42,775	45,669
12	43,579	13,801	14,373	24,817	25,850	27,908	38,523	43,536	45,954
13	45,495	12,664	15,646	24,445	25,884	28,147	37,953	44,214	46,056
14	40,860	10,207	14,454	22,305	24,784	26,946	35,324	41,375	45,174
15	41,318	9,151	14,934	21,726	24,847	26,791	34,604	41,105	45,009
16	42,022	8,310	15,442	20,984	24,240	26,808	33,681	40,976	44,942
17	40,536	7,160	15,098	20,026	23,632	26,323	32,548	40,295	44,617
18	41,515	6,396	15,628	20,102	24,482	26,811	32,668	41,510	45,195
19	36,544	5,008	13,884	17,628	21,786	25,560	29,729	38,766	43,924

Table 5.15. Projected Total Costs, By Program and Year (1976 Dollars)

Year	Base	Accelerated 1	Accelerated 2	Whole Herd Vaccination Low	Whole Herd Vaccination Medium	Whole Herd Vaccination High	Calfhood Vaccination Low	Calfhood Vaccination Medium	Calfhood Vaccination High
	Thousand dollars								
0	90,941	90,941	90,941	90,941	90,941	90,941	90,941	90,941	90,941
1	93,315	105,522	105,522	112,084	112,084	112,084	122,495	142,693	159,594
2	95,310	125,277	125,277	125,532	148,577	150,336	121,490	144,688	161,589
3	96,900	159,834	159,561	97,464	130,773	150,966	116,205	139,403	156,304
4	96,425	196,974	196,974	90,891	100,422	132,705	113,433	132,408	149,309
5	100,858	200,454	200,454	94,207	97,986	107,316	116,791	126,449	143,350
6	100,229	188,252	188,252	92,197	97,343	103,565	113,806	127,073	140,371
7	103,518	180,047	180,047	93,652	98,115	104,133	115,137	127,817	135,642
8	110,451	155,389	155,389	97,960	99,974	105,953	120,316	131,371	137,422
9	110,213	132,484	132,484	96,290	99,859	105,747	117,855	130,944	137,913
10	104,577	111,570	107,054	92,745	97,558	103,893	113,300	126,486	135,847
11	104,348	90,513	85,176	91,317	97,036	103,288	111,266	125,051	135,089
12	104,982	75,480	71,885	90,993	96,803	103,635	110,992	125,811	135,373
13	106,898	66,675	65,490	90,622	96,837	103,874	110,422	126,489	135,475
14	102,262	61,217	61,297	88,481	95,736	102,673	107,793	123,650	134,594
15	102,721	57,494	59,110	87,902	95,439	102,518	107,074	123,381	134,429
16	103,425	54,986	57,951	87,161	95,192	102,535	106,150	123,251	134,362
17	101,938	52,169	55,939	86,203	94,634	102,050	105,017	122,571	134,036
18	102,917	50,571	55,636	86,279	95,435	102,538	105,137	123,785	134,615
19	97,946	48,350	53,059	83,805	92,738	101,286	102,198	121,041	133,343

Table 5.16. Total Benefit/Cost Ratios, Various Program Alternatives Relative to the Base Program[a]

Program	Change In Benefits[b]	Program Costs	Base Program Costs	Marginal Program Costs[c]	Marginal Benefit/Cost Ratio[d]	Net Benefits[e]
	---------- Million dollars	----------	----------	----------	Ratio	Million dollars
Accelerated - 1	615.4	1,598.0	1,356.6	241.4	2.55	374.0
Accelerated - 2	535.8	1,597.6	1,356.6	240.0	2.23	294.9
Calfhood Vaccination-Low	651.9	1,515.4	1,356.6	158.8	4.11	493.1
Calfhood Vaccination-Medium	980.2	1,733.1	1,356.6	376.5	2.60	603.7
Calfhood Vaccination-High	1,064.2	1,896.2	1,356.6	539.4	1.97	524.7
Whole Herd Vaccination-Low	636.0	1,274.7	1,356.6	-81.9	7.76	718.0
Whole Herd Vaccination-Medium	802.2	1,390.0	1,356.6	33.4	24.02	768.9
Whole Herd Vaccination-High	894.3	1,504.6	1,356.6	148.0	6.04	746.3
No Program	-16,854.5	-0-	1,356.6	-1,356.6	-12.42	-15,497.8

a/ Computed for 19 years or from 1977 to 1995 and represent discounted present values.

b/ Total change in benefits of the program alternative over the basic program.

c/ Total program costs minus the base program costs.

d/ Change in benefits (column 1) divided by marginal program costs (column 4).

e/ Change in benefits (column 1) minus marginal program costs (column 4).

Table 5.17. Ranking of Program Alternatives by Selected Criteria

Program Alternative	Change in Benefits (Column 1 of Table 5.16)	Program Costs (Column 2 of Table 5.16)	Benefit/Cost Ratio (Column 5 of Table 5.16)	Net Benefits (Column 6 of Table 5.16)
	(Rank)			
Accelerated Option 1	7	7	6	7
Accelerated Option 2	8	6	7	8
Calfhood Vaccination Low-Level	5	5	4	6
Calfhood Vaccination Medium Level	2	8	5	4
Calfhood Vaccination High Level	1	9	8	5
Whole-herd Vaccination Low Level	6	2	2	3
Whole-herd Vaccination Medium Level	4	3	1	1
Whole-herd Vaccination High Level	3	4	3	2
No program	9	1	9	9

Table 5.18. Consumer and Producer Benefit/Cost Ratios, Various Program Alternatives Relative to the Base Program [a/]

Program	Consumer Sector					Producer Sector [b/]	
	Change In Benefits [c/]	Program Costs	Base Program Costs	Marginal Program Costs [d/]	Marginal Benefit/Cost Ratios [e/]	Change In Benefits [c/]	Marginal Benefit/Cost Ratios
	---------------Million dollars-------				Ratio	Mil. dollars	Ratio
Accelerated - 1	1,418.7	1,598.0	1,356.6	241.4	5.88	- 803.3	- 3.33
Accelerated - 2	1,249.0	1,597.6	1,356.6	240.0	5.18	- 713.1	- 2.96
Calfhood Vaccination-Low	1,476.6	1,515.4	1,356.6	158.8	9.30	- 824.7	- 5.19
Calfhood Vaccination-Medium	2,159.7	1,733.1	1,356.6	376.5	5.74	-1,179.5	- 3.13
Calfhood Vaccination-High	2,353.1	1,896.2	1,356.6	539.4	4.36	-1,288.9	- 2.39
Whole Herd Vaccination-Low	1,583.4	1,274.7	1,356.6	-81.9	19.32	- 947.4	-11.56
Whole Herd Vaccination-Medium	1,974.1	1,390.0	1,356.6	33.4	59.21	-1,171.9	-35.15
Whole Herd Vaccination-High	2,170.9	1,504.6	1,356.6	148.0	14.67	-1,276.6	- 8.63
No Program	-35,029.4	-0-	1,356.6	-1,356.6	-25.82	18,175.0	13.40

a/ Computed for 19 years or from 1977 to 1995 and represent discounted present values.

b/ The program costs, base program costs and marginal program costs indicated for the consumer sector also applies for the producer sector.

c/ Total change in benefits of the program alternative over the base program.

d/ Total program costs minus the base program costs.

e/ Change in benefits divided by marginal program costs.

Section 6 PROPOSAL FOR CHANGES IN THE GOALS AND NATURE OF THE UNIFORM METHODS AND RULES

One purpose of this Commission, was to review and make recommendations for changes in methods and rules approved by the United States Department of Agriculture's Animal and Plant Health Inspection Service as the minimum standards for achieving and maintaining certified and validated herd and area status. The U.S.D.A. adopts these standards and publishes them as, "Brucellosis Eradication Recommended Uniform Methods and Rules for Establishing and Maintaining Certified Herd and Area Status", (U.M.&R.) only after consideration of recommendations from many interested groups, including the U.S. Animal Health Association.

INTRODUCTION

The U.M.&R. have been acclaimed by some as the backbone of the cooperative state-federal brucellosis eradication program, because they provide a minimum standard for classifying herds or areas, according to compliance with program procedures, and the reported prevalence of brucellosis in a county or state, or in a herd of cattle. The brucellosis standards, as accepted by individual states either in their regulations or statutes, provide a minimum base for the orderly movement and marketing of cattle among the states.

On the other hand, the U.M.&R. have been criticized because the uniformity desired by some, does not seem to provide the "flexibility" desired by others to adjust to varying problems and conditions of management, marketing, and the prevalence of infection in different areas of the U.S., or even to competing interests within the cattle industry.

Each of these seemingly contradictory views of the U.M.&R. may have elements of validity, because nearly everyone wants to see his own concepts of flexibility adopted, in order to facilitate marketing and movement of cattle. However, to many cattle owners, the most important aspect is protection for their cattle, so they will not acquire brucellosis through purchase or movement of animals, or through neighborhood spread.

The differing viewpoints and needs of different segments of the industry, as well as of consumers and animal health officials, are reflected in the development and modification of the U.M.&R.'s from year to year. The U.S. Animal Health Association provides a forum for interested groups and individuals to express their views to the Brucellosis Committee, and through the Committee, to the Association, which then makes recommendations to APHIS, USDA for deletions, additions, or changes in the U.M.&R.

In order to obtain acceptance of these regulations by all groups involved, there often are significant compromises with principles of epidemiology and effective efficient disease control, that may adversely influence progress toward local eradication. Also, states appear to enforce the U.M.&R. selectively, as they try to meet local conditions. Most states have added to their own laws or regulations, requirements additional to those in the U.M.&R. Some of these are contrary to sound epidemiologic principles. There are therefore, 50 individual state programs, because of selective enforcement and interpretation of the U.M.&R., and the addition of special state laws and regulations.

SUGGESTED GOALS FOR U.M.&R.

We suggest that the basic goals of the U.M.&R. should include, but not be limited to the following:

Goal 1. To require governments and industry to promote a high degree of understanding of cattle brucellosis, and of the essentials of the U.M.&R. among those who have a need to know.

Goal 2. To establish criteria for classification of herds, states, or regions, which are based upon sound epidemiologic principles, and to use these criteria for optimal management and allocation of resources in order to protect brucellosis-free areas and herds from new infection, while assisting the few infected herds to become brucellosis-free.

Goal 3. To require a high degree of individual responsibility and accountability for actions which tend to perpetuate and disseminate brucellosis, and to use coordinated state-federal assistance to stimulate actions to prevent infection of cattle and people.

Goal 4. To provide guidelines for alternative methods and procedures which can assist owners, buyers, sellers and handlers of cattle prevent, or reduce the risk of transmitting brucellosis from one herd of cattle to another.

Goal 5. To provide guidelines for alternative methods and procedures to aid owners of cattle, once infection has been introduced into the herd, to prevent or reduce further spread within the herd, and to eliminate infection by use of individualized herd planning.

Goal 6. To utilize scientific knowledge and new results from continuing research as a fundamental base for development of the U.M.&R., in concordance with other factors affecting industry and the public.

Goal 7. To require governments to provide high quality professional and technical assistance to cattle owners and others, particularly in providing quality laboratory and epidemiologic services to aid in surveillance, diagnosis and prevention, with the goal of local eradi-

cation.

Goal 8. To provide maximum protection to states and cattle herds which are free from brucellosis, while offering maximum flexibility and diversity to meét local needs by emphasizing individualized herd planning which applies the best available technology to the specific epidemiologic situation.

BASIC CONCEPTS FOR REVISION OF U.M.&R.

Biologic Feasibility: The Commission has determined that "control toward local eradication" as defined is biologically feasible. This will require continuing surveillance, and research as in the present situation with foot and mouth disease (Section 4.6).

Biologic Knowledge: Biologic knowledge essential to accomplish local eradication is available, and has been utilized to reach the goal in many areas, although continuing research is recommended to improve present knowledge and increase the ease, effectiveness and efficiency of achieving the goal (Section 4.6).

Brucellosis Free: Most cattle herds in the country are free from brucellosis, since prevalence rates have been reduced from more than 120 infected cows/1000 cows tested in 1946, to less than 5/1000 in 1977; and from more than 400 infected dairy herds per 1000 to less than 1 infected dairy herd/1000 herds. The reported cases of human brucellosis have been reduced from more than 6,000 in 1946, to less than 300 reported cases in 1977. These accomplishments have come through high costs to governments and individuals over a 45 year period (Appendix D).

Sources of Infection: Only a few cattle herds, less than 7 of every 1000 herds, are maintaining the infection, and serving as the primary source of infection for the 993 herds in each 1000 which are fee of the disease. Protection of the vast majority of herds from this small reservoir is extremely costly to their owners and to the state and federal governments (Appendix D).

Need to Know: Most people have very little knowledge or understanding of brucellosis. They do not know how to protect themselves and their cattle because the reduction in prevalence has been accompanied by a reduction in the resources devoted to educational efforts that were so effective 15 to 30 years ago. This shift in emphasis arises out of the mistaken view that only the owners of the small number of infected herds have a need to know about the disease and the elements of the program. In fact the owners of herds which are free of brucellosis also have a need to know how to protect their herds, because they are at a high risk of infection from the small reservoir. Recent experience emphasizes that reintroductions can occur anywhere and actions based upon ignorance of sound epidemiological practices are frequently responsible (Sections 4.2-4.4).

Role of Government vs. Private Enterprise: Many people believe that government is too big, costs too much, tries to do too much, and has too many complicated regulations that people either do not understand, or find profitable to avoid. People appear to want lower taxes, less involvement of government and less rigid, detailed regulations. They appear to want more flexibility to consider individual situations, avoid stereotype solutions, and to use their knowledge and judgement in choosing among alternatives to reach a goal, such as local eradication of brucellosis. However, in the brucellosis program, many people in the cattle industry during the past 30 years, have asked for more government responsibility, more government regulation and more government expenditures to provide vaccine, to vaccinate calves, test cattle, pay indemnities, enforce regulations, and in some cases, to provide advice and assistance on how to prevent introduction, as well as to eliminate the disease from a herd (Section 4.7, 4.8, Appendices D, E, G).

When areas are free of disease, they ask for and need government protection to prevent importation of disease into their free area. Since the U.S. is free from foot and mouth disease, the cattle industry asks for, and receives, protection from imports of infected cattle or meat from outside the U.S. In many states which are free (or almost free) of brucellosis, the cattle industry and state officials have sought protection from importation of cattle infected with brucellosis so as to prevent reintroducing the disease. This need to protect free areas from brucellosis results in increased regulation and restrictions for areas which have not taken adequate actions to become free of the disease.

The Commission believes that local eradication is a public benefit, and believes that state and federal funds and manpower should be utilized to assist the cattle industry in achieving this public purpose, but the Commission also believes that there should be a change in attitude toward more self help. There should be a shift from sole governmental responsibility. to more industry involvement, with greater assumption of responsibility and accountability by cattle owners, truckers, handlers, order buyers, bankers and finance agencies, auction markets, commission companies and cattle dealers. In many states, it has been primarily the responsibility of government employees to prevent the spread of brucellosis by detecting infected animals and eliminating the disease from infected herds. Herd owners, cattle dealers, truckers, handlers and buyers often took no action for prevention, or they took actions which, in fact, increased spread of disease either because it was profitable, or because they did not have the appropriate knowledge. In other states, incentives furnished by health factors, economic implications and accountability, influenced individuals and groups in the dairy and beef industries to assume responsibility for preventing infection in their own and neighborhood herds, along with assistance from University extension personnel and practicing veterinarians in a shared responsibility with state-federal employees.

If people in the cattle industry really believe what they say about less government involvement, less detailed and complex regulations, and more flexibility to allow individual choice among alternatives to meet national goals, then individuals and groups in the cattle industry must accept more responsibility and accountability for preventing spread of brucellosis.

State and federal governments must still have some shared responsibility and accountability, but their role and involvement should shift to greater emphasis on providing quality professional and technical assistance and advice to individuals and groups with a need to know, or with special problems. State and federal governments should also provide quality laboratory and epidemiologic services to aid in diagnosis, surveillance and prevention as part of the accountability mechanisms.

Private enterprise, with coordination and technical assistance from government, promises greater efficiency and flexibility in methods to reach a national goal such as local eradication of brucellosis, if incentives are adequate.

Individual Choice and Accountability: If the national goal of control leading to local eradication is to be continued, and if there is to be a shift of primary responsibility to all segments of the cattle industry working together with government, there should be more flexibility of program and more individual choice of methods and procedures to prevent spread or to eliminate brucellosis from a herd, in accord with individual situations and local conditions. There must be a recognition of the need to protect brucellosis free herds from reintroduction of infection, as well as of the need to eliminate brucellosis from infected herds. Economic, social and public health incentives for individual accountability must be clearly evident. These incentives should reward those who take positive actions to learn about brucellosis and to keep their herds free of infection. Economic and social assessments should fall primarily on those who fail to take positive actions to keep their herds free, or on those who specifically take actions which increase the probability of spread of brucellosis to other cattle or to people (Section 4.6, 4.9).

Such a system of positive and negative incentives should be widely publicized, and should not take effect until an agreed upon date or dates. This would provide a period of time for education and development of a framework of assistance and incentives. It would also provide time to develop and implement more effective private mechanisms for enforcement, and for recovery of damages, than are presently available. This could supplement the standard public agency enforcement of laws and regulations which is cumbersome, and relatively ineffective in reducing or preventing practices that are known to spread brucellosis. (Section 4.7) It should be recognized that freedom from the disease reduces the need for regulations and restrictions in the free areas, and ultimately

increases the freedom of movement of cattle. Thus, freedom from disease means greater freedom for industry and less state or federal involvement, and ultimately at reduced cost of public funds (Appendix D).

RECOMMENDATIONS FOR CHANGES OF U.S.D.A. UNIFORM METHODS AND RULES FOR BRUCELLOSIS PROGRAMS

The Commission agrees that brucellosis is a severe and debilitating disease in people, and is a serious disease of cattle, swine, and goats. Elimination of brucellosis through control toward local eradication in the several states of the United States is of public benefit, since people contract the disease directly from animals or their products, and it is necessary to provide protection to both the livestock industry and the public health. The Commission recommends that cattle infected with or exposed to brucellosis, and cattle of unknown brucellosis status be declared a threat to other cattle and to human health. Within this context, and in accord with the Goals listed on pages 6-2 and 6-3, the Commission also recommends changes in the U.M.&R., with incentives to encourage adoption of preventive measures, which contribute to effective control leading toward local eradication of brucellosis. These recommendations are not intended to include all changes that may be desireable. It is not the Commission's charge to rewrite the U.M.&R. This is a proposal which would provide guidelines for final determination by state and federal governments, the industry and the public through the existing channels of adoption of regulations.

A. Permanent Non-Duplicative Identification of Individual Cattle

1. Each state should have, and enforce, laws and regulations that require all cattle to have permanent non-duplicative individual identification, from the time of first handling for movement or change of ownership with or without payment. Such a requirement should be included in the U.M.&R.

2. The same requirement for permanent non-duplicative individual identification of all cattle that are moved across state lines should be included in the U.M.&R. and the Code of Federal Regulations.

Proposed Effective Date:

To be effective as soon as possible in each state and not later than December 31, 1981.

Purpose:

The purpose of this requirement is to strengthen present identification requirements to provide for better, more permanent identification; to aid in tracing individual animals through one or more changes of ownership to the herds of origin, to aid in finding the source of exposure to infection, and in preventing further spread from that source.

Identification is also necessary if there is to be appropriate accountability for the person or persons who did not take positive actions to prevent exposure of cattle to other cattle with brucellosis.

B. Cattle Dealer's Responsibility

1. Each state should have and enforce regulations that require all cattle dealers to keep records which are readily retrievable, and in a form that will trace cattle, by means of approved or permanent identification numbers, from buyer to seller, or from seller to buyer.

2. Each state should have and enforce regulations that require all handlers of cattle, sellers, buyers, auction markets, truckers or any other handlers to take positive action to prevent potential exposure between known brucellosis reactors or known "S" branded cattle and all other cattle. (Part II K, U.M.&R., 1977).

3. States should consider enactment of administrative procedures acts which would provide a mechanism for determination of liability for failure to abide by these requirements and to issue orders to prevent such failure. (See Section 4.7 and Appendix I for a more extensive treatment of the rationale for such an administrative procedures act as it might apply to all program elements).

Proposed Effective Date:

To be effective as soon as possible but not later than December 31, 1981.

Purpose:

The purposes of these requirements are to aid in traceback of serologic test reactors on change of ownership or movement, to increase detection of infected herds, and to aid in preventing spread of brucellosis.

C. Educational Warranty

1. Provisions of the Warranty:

Each state should have laws and regulations which specifically provide that for every change of ownership of cattle, there must be a bill of sale, which provides the permanent individual identification numbers of the cattle involved, and shall also provide the legal names and addresses of the sellers and the buyers.

Each state should also provide that every bill of sale be accompanied by an educational warranty that would inform the buyer that the cattle are warranted free of infection with *B. abortus*. Warranties

should be used solely for educational purposes during the first year after implementation, until a predetermined certain date, when the legal aspects of the warranty would become effective.

Such laws and regulations should also authorize appropriate assistance from the state animal health agency to the buyer, when requested, to provide aid in diagnosis, and to provide expert testimony in any legal proceeding related to the warranty.

The law should provide that if the warranty is ruled defective, the buyer could recover a reasonable sum for damages, which would have a maximum limit in relation to the purchase price; however, in addition to limited damages, the purchaser should recover all costs, such as attorney's fees, expert witnesses, etc., reasonably incurred in connection with obtaining a judgement that the warranty was defective.

Warranties should assure the buyer that the sellers have followed known and accepted procedures to be reasonably certain that the cattle were not infected or exposed to brucellosis during the 90 days prior to change of ownership and that the handlers have followed provisions of the U.M.&R. to prevent exposure.

2. Educational Information:

For educational purposes, the warranty should be securely affixed to the front of the bill of sale or change of ownership document, and should be printed in easily readable type on contrasting paper, which is a color distinctly different from the color of the paper utilized for the bill of sale. The educational part of the warranty statement should provide, in plain English, a short explanation of the hazards of purchasing cattle that have been exposed to or infected with brucellosis, the usual absence of clinical signs of disease, the steps that should be taken by the producer to reduce these risks, the desirability of post purchase serologic testing, preferably at 30 to 90 days, but under some conditions up to 150 days. The results of such tests can be used to provide reasonable evidence as to the validity of the warranty. The statement should also provide a synopsis of the warranty law, and the telephone numbers and addresses of the State Veterinarian and the appropriate state legal authority.

3. States and the federal government should consider enactment of administrative procedures acts, which would provide a mechanism for determination of validity of claims under the warranty, (see section 4.7 and Appendix I for a more extensive treatment of the rationale and elements of such an administrative procedures act as it might apply to all program elements).

Proposed Effective Date:

The effective date in each state should be as soon as possible for the educational part of the warranty, but not later than December 31, 1981 for all states, and for interstate as well as intrastate movement. States should specify a period of one year for educational use of the warranty prior to actual effective date of implementation of the legal aspects of this private warranty. (Buyers may also seek a remedy at present in the Federal District Courts under Section 2-314 of the Uniform Commercial Code which deals specifically with implied warranties. (see Section 4.7, and Appendix I).

Purposes:

(a) To provide educational information in an efficient manner to both buyers and sellers of cattle who need to know, since they are either at greater risk of introducing brucellosis into their own herds, or of spreading it to others;

(b) To provide the educational material at the time the buyer and the seller each has an individual need to know and is most likely to read and learn;

(c) To provide additional assistance to encourage self-help and provide incentives for assumption of greater responsibility and accountability by buyers, handlers and sellers of cattle;

(d) To provide alternative legal mechanisms to supplement, but not to replace, public legal enforcement of other laws of state and federal governments. Even as low as 15 to 20% random checking of warranties will serve as an effective method to gain the attention and positively influence the actions of owners and dealers to sell only cattle that have not been exposed to, or infected with brucellosis.

D. Individualized Herd Programs

1. Laws and regulations, similar to Sections 10492 through 19495 of the California Food and Agriculture Code are recommended for each state. The California statute provides that for each brucellosis infected herd, the owner, his veterinarian, and a veterinarian of the animal health agency, shall develop a plan for eliminating brucellosis from the infected herd. In California, the plan is formalized as a memorandum of agreement between the owner and the state animal health agency. It establishes owner responsibility for following the plan, or developing an acceptable modified plan. If the plan is not diligently pursued by the owner, he becomes responsible for reimbursing state government for costs incurred in eliminating brucellosis from his herd. (Se complete text of California law Appendix I).

Proposed Effective Date:

Each state should use the California law on this subject as a model, and adopt similar regulations or laws as soon as possible, but not later than December 31, 1981. The states must plan training of their professional personnel to assure that such herd plans will be epidemiologically appropriate.

Purposes:

This proposal is recommended to encourage individualized, flexible planning and participation by the owner in a shared responsibility with government for prevention and control of brucellosis toward local eradication. It would enlist participation by the practicing veterinarian at the request of the owner, ensuring consistency of advice.

E. Public Notification of Herd Quarantine

Each state should have and enforce regulations which require that the status of any herd placed under quarantine for brucellosis be made known immediately to owners of adjacent herds, herds sharing common pasture, or herds with any other known or suspected direct or indirect contact, including previous purchase from the quarantined herd. This public notification is recommended as an integral part of the surveillance system to alert owners of these potentially exposed herds to the quarantine, and the need for surveillance now with prevention in the future. Similar notification should be made when the herd quarantine is released.

Proposed Effective Date:

To be effective as soon as possible but not later than December 31, 1981.

Purpose:

The purpose of this public notification is to alert other herd owners to the quarantine, immediately, to help them to evaluate the potential risk to their own herds, to help them to arrange for testing, to help them to prevent future exposure from the quarantined herd, and to encourage better surveillance and protection for brucellosis-free herds.

F. "S" Branded Cattle

Each state should have and enforce regulations which require that all cattle shall be "S" branded (1) when they have been exposed to brucellosis reactors, unless they are returned directly to herd of

origin for quarantine until appropriate release; (2) when they are test-eligible cattle of unknown status, which are being moved or sold without appropriate serologic testing as required by the classification of their state of origin. "S" branded animals should be restricted in their movements, and should be moved only directly from a point of concentration or sale to a quarantined feedlot, or to immediate slaughter.

Proposed Effective Date:

As soon as possible but not later than December 31, 1981.

Purpose:

To reduce the spread of brucellosis by identifying, and restricting movement, of known exposed cattle and of cattle of unknown status from unknown herds of origin which have not fulfilled test requirements. Cattle of unknown status, which have not fulfilled herd of origin or serologic test requirements must be considered to be infected or exposed to brucellosis until shown otherwise, and therefore must be quarantined at origin or "S" branded.

G. Proposed New Classification of Brucellosis Status for States

Size of Classification Area: States are recommended as the unit for classification of brucellosis status because states are the only legal entities with authority, personnel, resources and responsibility to deal with other states, the federal government and livestock disease problems within the state.

1. CLASS A STATES (Brucellosis-Free)

a. States must maintain zero infection due to field strain *B. abortus* for more than 12 months, except for reintroduction of infection from outside the state, or from other species, with no secondary spread to other cattle within the state. (Assume field strain until state officials show otherwise by culture and epidemiologic evidence).

b. States must demonstrate effective surveillance and prevention of transmission to other herds. (Effectiveness can be defined as; (a) a function of an average national reactor rate on initial herd tests compared to initial herd test of the herd being evaluated; (b) as judged by prevention of secondary transmission, and by epidemiologic evaluation).

2. CLASS B STATES (Intermediate Risk of Brucellosis)

a. States must not exceed an average 12 months prevalence rate of 1% for herd infection with field strain *B. abortus*. (Assume field strain until state officials show otherwise by culture and epidemiologic evidence).

b. No county in the state may have an annual prevalence rate exceeding 2% of the herds, except in counties under current area test.

c. States must maintain annual prevalence rates not to exceed 5 reactors per 1,000 cattle tested. (Prevalence is to be calculated using "not previously known" reactors as the numerator, but excluding reactors from known quarantined herd. The reactor rate should be evaluated by results of supplemental tests and epidemiologic data, as appropriate to detect additional reservoirs of infection).

d. States must maintain effective surveillance with effectiveness defined as in Class A states.

e. States must maintain effective implementation of U.M.&R. requirements as judged by administrative review, and epidemiologic evaluation.

f. States must make continued progress in reducing prevalence of brucellosis as determined by epidemiologic evaluation.

3. CLASS C STATES (Higher Risk of Brucellosis)

a. States which do not meet the requirements for Class A or Class B states.

b. States must make progress in reducing prevalence of brucellosis as determined by epidemiologic evaluation.

H. Recommendations for Vaccination with Strain 19 *B. abortus* (see Table 1)

Proposed Effective Date:

As soon as possible but not later than December 31, 1981.

Explanation:

Strain 19 vaccine has been very valuable, when appropriately used, in protecting cattle against field strain *B. abortus*, and particularly when 90-100% calfhood vaccination is practiced. Previous experience with vaccination of adult cattle, and results from recent studies using a reduced dose of vaccine for adult cattle are very promising. They appear to provide data which, at least, indicate no harm from the procedure if appropriately controlled, and at best, indicate advantages in detecting incubating infection, and providing useful protection, particularly when accompanied by good management practices and removal of known infected animals from the herd (Section 4.4).

TABLE I

RECOMMENDATIONS FOR VACCINATION OF CATTLE WITH STRAIN 19
BRUCELLA ABORTUS VACCINE AND CHANGES IN THE UNIFORM METHODS AND RULES

	Vaccination Recommendations for Present Changes in 1978-79	Recommendations for Future Changes When Research Results Provide Additional Data on Reduced Doses and Alternate Route for Vaccination
CLASS "A" STATES Brucellosis-Free	Class "A" '78-79 1. Calfhood vaccination - same as present UM&R 2. Recommend vaccination of all female calves that may be exposed in the future or may be sold.	Class "A" future 1. Extend age for official calf vaccination to 12 months and encourage vaccination for calves that may be sold or exposed in the future. 2. Change test-eligible age to 16 months of age for both beef and dairy heifers with official calf vaccination "OCV".
CLASS "B" STATES Intermediate Risk of Brucellosis AND CLASS "C" STATES Higher Risk of Brucellosis	Class "B" and Class "C" '78-79 1. Calfhood vaccination - same as Class "A" '78-79 2. Recommend calf-vaccination -- same as Class "A" '78-79 3. Provide rules for judicious, controlled use of "Whole Herd Vaccination" of brucellosis negative herds with high risk of infection (see suggestions in the text). 4. Change rules for "Individual Herd Plan with Adult Vaccination" as presently in UM&R. a. Include herds of unknown status which are determined to be at high risk of infection -- handle same as infected herds. b. Provide for quarantine release of previously infected herds, including adult vaccinates, under appropriate conditions of time and negative serologic tests (see suggestions in the text).	Class "B" and Class "C" Future 1. Extend age -- same as Class A Future 2. Change test-eligible age -- same as Class A Future 3. Whole herd vaccination -- same as Class B & C '78-79 4. Adult vaccination -- same as Class B & C '78-79

1. Recommendations summarized in Table I for vaccination beginning in 1978-79, are based on sound epidemiologic judgement, and the provisions of the 1977 U.M.&R. There is a new recommendation to allow owners of herds not infected, but at high risk of becoming infected with brucellosis, to request "whole herd" vaccination. Whole herd vaccination means that animals older than the age for calf vaccination could be vaccinated under specified conditions with a reduced dose of vaccine, as now provided in the U.M.&R. for adult vaccination of selected herds with known infection. This new recommendation for "whole herd" vaccination of high risk herds involves the concept of prevention of spread between herds and could be applied, following official approval, by owners who are neighbors to infected herds. This should aid in preventing spread not only between herds but also to reduce spread within the neighbor's herd if it should become infected. The recommendation for whole herd vaccination involves controlled, judicious use similar to 1977 U.M.&R. requirements for "adult vaccination".

2. Recommendations summarized in Table I for future vaccination procedures are based on data from previous experiments, and the limited data now available from experiments being conducted at Ames, Iowa by U.S.D.A., to determine the most appropriate dose of vaccine for vaccination of calves, non-pregnant yearlings and first calf heifers. Our recommendations for the future are based on projected results of available data. They should be reviewed when present experiments are completed and revised, as necessary.

3. Explanation of Recommendations for 1978-79.

a) Class A States 1978-79 Recommendations:

(1) Calfhood vaccination as defined in the 1977 U.M.&R. is recommended for all female calves that, in the future, may be sold and/or exposed to brucellosis.

b) Class B and Class C States 1978-79 Recommendations

(1) Calfhood vaccination as defined in the 1977 U.M.&R., is recommended for all female calves that, in the future, may be sold and/or exposed to brucellosis (same as for Class A states).

(2) Whole-herd vaccination is recommended for herds at high risk of becoming infected with brucellosis, provided that rules for controlled judicious use are developed such as:

Such procedures may be initiated only after written permission is obtained from the state and federal officials directly responsible for the program activities in the state in which the herd is located.

Herds of unknown status should be considered potentially infected, or incubating infection, and be required to follow the same rules as

known infected herds.

(3) Herds of known status, i.e. "qualified herds" should be handled according to the following suggestions:

(a) A blood sample should be obtained from all test-eligible cattle for serologic testing. If all tests are negative, continue to treat as a qualified herd at high risk, but if any cattle are reactors, treat the herd as a potentially infected herd at high risk, and follow the same rules as for herds of unknown status and known infected herds.

(b) In qualified herds with negative serologic tests, but at high risk, all eligible calves should be calfhood vaccinated and identified. Within 10 days after serologic testing all other female cattle should be vaccinated with a reduced dose of Strain 19 vaccine and identified with an official "AV" (adult vaccination) tattoo in the ear and an "AV" ear tag, as well as the permanent individual animal identification. Following vaccination, the herd would be placed under quarantine and tested approximately 90 days following vaccination, and at not less than 30 day intervals thereafter, until two consecutive negative tests were obtained to release the quarantine. The adult-vaccinated cattle could move as test-eligible official vaccinates as provided in the present U.M.&R. for official calfhood vaccinates.

(4) Individual Herd Plan with Adult Vaccination is recommended as provided in Part II, page 7, U.M.&R. 1977 for known brucellosis infected herds, with the following suggested changes:

(a) Include, as eligible herds, those herds at high risk of brucellosis infection which are potentially infected, i.e. of unknown status and not a qualified herd, or a previously qualified herd, in which one or more reactors were found at time of testing prior to whole herd vaccination.

(b) Change requirements to allow movement of these cattle (previously adult vaccinated in an infected herd with an "AV" brand on the jaw) provided the herd has been released from quarantine; provided the branded cattle themselves meet any additional requirements for movement of test-eligible cattle within, to, or from Class B or C states; and provided the cattle are individually identified as "AV" branded cattle on the official permit for movement and the bill of sale and warranty.

(5) Explanation of Future Recommendations:

(a) Class A States Future Recommendations:

(1) Extend age for official calf vaccination to up to 12 months and use appropriate reduced dose of vaccine.

(2) Change test-eligible age to 16 months for both beef and dairy heifers with official calf vaccination. This should reduce problems of identifying those vaccinated animals which become infected and spread the infection before they are tested at 20-24 months of age.

(b) Class B and Class C States Future Recommendations:

(1) Extend age -- the same as Class A Future (above)

(2) Change test-eligible age -- the same as Class A Future

(3) Whole-herd vaccination -- the same as recommended for Class B and C States 1978-79 (above).

(4) Individual Herd Plan for Adult Vaccination -- the same as recommended for Class B and C States 1978-79 (above).

It is anticipated that on the basis of on-going and new research, that some of the restrictions on vaccination will not be necessary in the future. It may even become possible to eliminate the need for "official vaccination" if the potential post-vaccinal serologic titers no longer need special consideration and all cattle are moved or sold on the basis of herd history, all are test-eligible regardless of age, and all are warranted free of brucellosis.

I. Alternative Options for Serologic Test Requirements

Proposed Effective Date:

As soon as possible but not later than December 31, 1981.

Explanation:

Serologic tests are important as aids to diagnosis of brucellosis, along with known herd history and other epidemiologic data. Since brucellosis in cattle has a variable incubation period, it is helpful to know if and when a cow may have been exposed to *B. abortus*. If herd history is not available, or is not trustworthy, then it may be necessary to have at least two, and preferably three, serologic tests of the individual cow, at intervals of not less than 90 days, with no exposure during the 180 day test period, in order to provide a high degree of assurance that the cow is free from brucellosis. Serologic diagnosis of brucellosis, as in other infectious diseases, is based on probability of detection of evidence of infection. Thus, the more negative examinations or tests, and the greater the period of time with no exposure, the greater the probability that the animal is free from the infectious disease (Section 4.4).

In accord with these concepts, the Commission has presented several options for consideration as changes in the U.M.&R. pertaining to serologic test requirements, for change-of-ownership or movement of cattle. Each of these options provides a different degree of protection for the seller and the buyer.

(1) Comparison of Options and Classification of States

Option #1 provides more assurance than Option #2 that cows are free of brucellosis when they move or change ownership. However, to gain this assurance, Option #1 requires more information about the herds of origin, or more tests over a longer period, than is required in Option #2.

Gradations of assurance are also provided by classification of the status of the states. Risk of transmitting brucellosis from herds located in Class A states is very small, since Class A states have zero infection rates. Risk of transmission is intermediate in Class B states, and higher in Class C states, which have more infected herds. Thus, there are few restrictions on movement and change-of-ownership in Class A states. Requirements are more restrictive in Class B states and most restrictive in Class C states, where herd infection rates are higher.

(2) Post-Purchase Tests

Options #1 and #2 have a key provision in states in Classes A, B, & C which is designed to motivate people who purchase cattle to have them tested at 30-150 days post-purchase, as a check on their brucellosis status. At present, unscrupulous individuals, and people who are unaware of the status of their cattle, may sell cattle which previously had been exposed to brucellosis, but had not yet developed serologic titers because they were in the incubation stage. A serologic test at 30-90 days post-purchase will have a high probability of detecting a rising titer and show that such an animal has been exposed and infected at a previous point in time.

This procedure of requiring two serologic tests at two points in time is epidemiologically sound, when correlated with probable incubation period and post-purchase quarantine to prevent post-purchase exposure. More than half of the states in the U.S. already have adopted similar regulations requiring quarantine at destination and a post-purchase test of cattle originating from selected high prevalence states.

These recommendations for the U.M.&R., to expand present state requirements for post-purchase tests of cattle in Options #1 and #2, are important because they relate to responsibility and accountability of the seller. If the seller knows that there may be a post-purchase test in 30-150 days following purchase, he will be encouraged to have more assurance that the cattle which he sells are from a brucellosis free herd and have not been exposed prior to sale. The concept of a sero-

logic test following purchase (test at a second point in time) along with the educational warranty provides an improved approach to control leading to local eradication.

(3) Explanation of Option #1 (see Table II)

a) Option #1 provides more protection for herds in all states, including Class A brucellosis-free states, but also provides more restrictions for the Class B and Class C states where the risk of transmitting brucellosis is higher.

b) A "Qualified Herd" as used in Table II should be defined as, and have the same requirements as "Certified Brucellosis Free Herds", 1977 U.M.&R. Part IV, pages 9 and 10.

c) "Test-eligible" cattle are defined as: official vaccinates of dairy breeds 20 months of age or over; official vaccinates of beef breeds 24 months of age and over as evidenced by the presence of the first pair of permanent incisor teeth; or official vaccinates under those ages that are parturient (springers) or post-parturient and all other cattle six months of age and older except steers, spayed heifers and "S" branded cattle.

d) Requirements to move cattle from one state to another, or within the state, are the same for any given state of origin. This follows the principle of giving the same protection to every state of destination. Class B states must follow the same requirements to sell cattle within the state or to Class C states as they must follow to sell cattle to Class A states or other Class B states. This prevents "dumping" cattle on other states and gives equal protection to each state.

(4) Explanation of Option #2 (see Table II)

a) Option #2 provides less protection and greater risk of transmitting infection for all states but it requires fewer restrictions for Class B & C states.

b) Definitions for "Qualified Herd" and "test-eligible" cattle are the same as recommended and defined in Option #1 (above).

(5) Explanation of Future Options (see Table II)

a) This option provides for fewer restrictions on movement or change-of-ownership but is not recommended until the prevalence of brucellosis in all states is greatly reduced and most states are brucellosis free areas, with brucellosis free herds well established in the others.

b) This option is recommended when all states would meet the requirements for Class A or Class B, and there would be no Class C

states. In addition all states would have less than 1/3 of maximum prevalence allowed for Class B states in the current definition. This reduced prevalence would minimize potential for transmission of infection.

c) Required post-purchase tests for animals sold or moved from Class B herds would utilize statistical sampling techniques, thus reducing costs, commensurate with the reduction in prevalence, without significantly increasing the risk. This is also dependent on the acceptance of individual responsibility and accountability within the framework of the post-purchase testing plan and the relative success of the education and warranty systems to provide knowledge and incentive for the buyer as well as the seller of cattle.

d) The principle of stratified sampling on a sound statistical basis can be applied to all surveillance procedures other than the milk ring test, as the prevalence of the disease is reduced, so that other continuing surveillance costs may likewise be reduced.

J. Suggestions Related to Part I - Definitions, U.M.&R. 1977

Proposed Effective Date:

As soon as possible but not later than December 31, 1981.

1. Reactor, Suspect, Negative - It is suggested that these definitions be adjusted to provide for further evaluation of official vaccinates by the Complement Fixation test or Rivanol test, when requested, and the history of the herd of origin is adequate.

2. Herd Test - It is suggested that the definition of herd on page two be improved to conform with good epidemiologic principles.

3. Official Vaccinate - The Commission recommends, that when reduced doses of Strain 19 vaccine and/or other routes of administration are approved for official use, that consideration be given to revising the maximum age of vaccination in accordance with the results of research and epidemiologic evaluation of field practices (see Table I and Recommendation #8).

4. Successful Traceback of Reactors - There is reason to question the inclusion of animals traced to premises where all animals were said to be sold for slaughter (Appendix D). The Commission believes that this should be reviewed and realistically limited in terms of claiming a successful traceback. In addition, an effective traceback should be defined as one which is made within thirty days of the date that the laboratory test was performed, and where the issuance of a quarantine and the testing is accomplished within 60 days' thereafter.

5. Qualified Herd - This definition should be changed to be the same as the present definition of a Certified Brucellosis Free Herd.

K. Suggestions Related to Part II, U.M.&R. 1977

1. Quarantines.

Language should be added which recommends that all states institute a check test of the herd not less than 6 months after removal of the quarantine.

2. Classification of Cattle

a. It is recommended that the Card test be used as an official test to classify cattle as reactors only (1) when conditions and time are such that no other test is available, or (2) on request of the owner and/or his agent because of time or situation constraints. Card tests may be used as screening tests to classify animals negative on surveillance samples collected at slaughter and at livestock markets except as previously stated. On tests of suspicious and known infected herds, especially if they are not vaccinated, Card tests may be used in addition to other official tests to aid in evaluation.

b. Reclassification of reactors should be amended to include language providing for the use of supplemental tests, particularly the Complement Fixation and Rivanol tests, to classify animals which have been vaccinated with Strain 19 vaccine.

c. Language should be added which defines the use of Complement Fixation and Rivanol tests under appropriate conditions for the classification of cattle as official reactors, or as negative for the Complement Fixation or Rivanol tests.

3. Laboratory Services

Each state or region should be required to provide quality laboratory services including the Complement Fixation or Rivanol test and bacteriologic culturing services to isolate *B. abortus* from milk and tissues.

APHIS should develop a cooperative system with states and universities for regular review of training and performance of laboratory personnel as well as assisting laboratories to develop systems of continuous quality control for all laboratory tests and culturing procedures, with evaluation by a review committee as needed, but at least once in each 3 year period.

4. Epidemiologic Services

Each state should be required to provide quality epidemiologic services to aid veterinarians and herd owners in prevention and control of brucellosis leading toward local eradication.

This requirement should include provisions that: state-employed veterinarians, with brucellosis program responsibilities, shall attend the APHIS Brucellosis Epidemiology short course within the first year of their assignment, that private accredited veterinarians shall participate in a structured program of continuing education in Veterinary Services programs as a condition of maintaining accreditation; that state and federally employed livestock inspectors have in their job descriptions a requirement for a structured program of continuing education on program elements.

Each state should make provision for the Animal Health Agency to notify the State Public Health Agency of the imposition of each quarantine for brucellosis, so that the Public Health Agency may take appropriate educational steps.

5. APHIS should develop a cooperative system with states and universities for regular review of the federal program and each state brucellosis program in terms of qualifications and performance of personnel and implementation of U.M.&R., with evaluation by a review committee as needed, but at least once in each 3 year period.

L. Suggestions Related to Part IV, U.M.&R. 1977

1. See Recommendations 7 and 9 and Table II.

2. Certified Brucellosis-Free Herds of Cattle should remain essentially the same and be equal to "Qualified Herd" requirements. It appears less confusing to have only one set of requirements.

M. Surveillance Procedures - Recommendations

Proposed Effective Date:

As soon as possible but not later than December 31, 1981.

Effectiveness, efficiency, cost and even feasibility of various surveillance procedures are influenced significantly by changes in the cattle industry and the patterns of ownership which reflect biologic, economic, social, political, technologic, business and government influences (Section 4). Therefore the planning, implementation and evaluation of surveillance procedures must reflect consideration of all these influences.

1. Since there are continuing changes in these influences, it is recommended that a mechanism be established for continuing evaluation of surveillance procedures with provisions for adjustment to most effectively and efficiently use limited resources of money and personnel.

2. Since any single method surveillance is particularly vulnerable, and may fail to detect infection when other conditions have changed, it is recommended that an appropriate mix of surveillance procedures be utilized to recognize variations which might be introduced by such factors as the phase of cattle cycle, or other short or long term trends.

It is recommended that the MCI should not be used as the "sole" or primary method of surveillance and/or classification of states. Combined strategies of testing at slaughter, or change of ownership or movement, post-purchase, contact herd testing, etc., along with supplemental serologic tests, milk ring tests, bacteriologic culture of aborted fetuses, diagnostic referrals, and sound epidemiologic judgement are recommended for consideration, with varying emphasis as appropriate, for surveillance and for classification of states.

Examples:

a. Although the MCI rate is useful as a relative index of prevalence of infection in previously undetected herds, it is slower than the milk ring test in detecting infected dairy herds. During the accumulation phase of the cattle cycle, when many owners are building herds by purchase, the MCI will miss herds which do not send cattle to sale or slaughter. The MCI is of greater value, and should be emphasized more during the liquidation phase of the cattle cycle when more cattle are going to sale and slaughter. This implies improved performance in identification and handling of samples and of follow up.

b. Although the milk ring test is very useful, it may be incorrectly utilized in today's larger herds, and when preservatives are used in the milk. Thus laboratory and field personnel should give continuing attention to procedures being used in collecting milk and conducting the milk ring test. It also should be conducted 3 or 4 times on each herd each year. It is further recommended that a mechanism be established in each state to assure that each dairy herd is sampled during each round of collection.

c. Since as many as 60% of replacement breeding beef females may be sold on a direct change-of-ownership without passing through a market, it is important to utilize change-of-ownership testing to provide adequate surveillance.

d. Post-purchase testing is not only useful in promoting accountability, it also provides additional information at a second point in time for surveillance and detection of infection.

e. Additional surveillance information can be gained from tests of herds wishing to be classified as "Qualified" or "Certified Brucellosis-Free".

f. Diagnostic referrals should also be considered in evaluating and planning surveillance. Some countries rely almost exclusively on diagnostic referrals for surveillance and put great emphasis on receiving, at the diagnostic laboratories, all aborted fetuses or calves which die within a few days following birth. Culture of the fetuses and calves have been very useful in many areas, however, in other areas, depending on climate, terrain and management, it would be difficult to utilize abortions as a significant means of surveillance.

Research and Research Policy

The original charge to the Commission included "An investigation of the nature and present availability of knowledge essential to the goal of eradication." That part of our mission has been met, to a considerable degree, in the compilation and evaluation of research in the report of the Subcommittee on Brucellosis Research of the National Academy of Sciences, and by the Texas A & M University Symposium.

In our public hearings, and in the position papers we received, there was a consistent and continuing call for increased research. The most generally suggested areas were: improvement of diagnostic systems (especially distinguishing between vaccine induced antibody and that induced by field strain infection), improved vaccines, establishing the importance of "latent" infection in calves of infected dams, and the importance of wildlife as sources of infection for cattle.

A more comprehensive listing of topics for research priority was adopted by the 29th Annual Conference on Brucellosis Research, in Chicago, on November 28, 1976. It is presented here:

"1. The development over the last decade, of modern methods for the isolation and characterization of macromolecules interpretation of earlier work difficult, and at the same time opens opportunities for basic advances, and for applications to all aspects of the immune response. The need for investigations on these contemporary methods has been recognized in many of the following recommendations.

"2. Our understanding of the pathogenesis of brucellosis has not kept pace with contemporary methods of investigation. This is an area which should, when properly exploited, produce significant basic, and ultimately, useful information.

"3. Studies basic to the taxonomy of the brucellae have a direct bearing on many of the following items, and therefore warrant continuing emphasis.

"4. Investigation of the effects of dosage and route of vaccination on cell mediated immunity and resistance to challenge exposure.

"5. Continued studies of cellular immunity to increase our knowledge of the phenomenon and determine its applicability to diagnosis and monitoring of immunogenesis.

"6. Investigations of nonviable immunizing agents for cattle, including specific agents and nonspecific stimulators of cellular immunity.

"7. Investigation of the course and persistance of brucellosis in calves, particularly the nature and prevalence of latent infection in progeny of infected dams.

"8. Analysis of the phenomenon of failure of infected animals to manifest serological responses prior to abortion, including the use of a variety of antigens, the whole range of immunoglobulins, and the cell mediated immune system.

"9. Investigation of means and products for vaccinating appropriate susceptible wildlife populations such as the elk and bison in the western states and the Alaskan reindeer, with the possibility that data generated may stimulate further examination in other species.

"10. Continued study of canine brucellosis caused by _B. canis_, including development of standardized and more specific diagnostic procedures, chemotherapy, and immunogenesis.

"11. Continued study of the physiology of _Brucella_ organisms and biological properties of cell components."

In response to the clearly expressed need for additional research, the 95th Congress appropriated additional funds for research on brucellosis, specifically directing "...the Secretary to present to the Committee a timetable for development of an effective adult vaccination program for eradication of brucellosis."

An annotated listing of current research and field investigations funded in whole, or in part, by the U.S. Department of Agriculture follows:

Subject: Current Research and Field Investigations
Funded in Whole or in Part by USDA

1. Projects sponsored by SEA-Federal Research.

   A. University of Alaska - Dr. Robert A. Dieterich.

      1. Title - Pathogenesis, Diagnosis, and Control of _Brucella_

suis, Type 4 Infection in Ruminants.

2. Objectives.

a. Evaluate the efficacy of brucellosis vaccines in reindeer and develop an effective immunization program.

b. Compare pathogenesis of *B. suis*, type 4 infection in reindeer and laboratory animals.

c. Evaluate diagnostic tests for ability to detect infected reindeer.

B. Auburn University - Dr. T. T. Kramer, Dr. A. I. Swann, (Dr. P. H. Klesius).

1. Title - Biological Control of Bovine Brucellosis by Stimulation of Cell-Mediated Immunity.

2. Objectives.

a. Prepare and study certain brucella antigens to show the development of cell-mediated immunity in brucellosis of cattle under experimental conditions.

b. Define the cell-mediated immune response in cattle following vaccination with Strain 19 vaccine.

c. Study methods and procedures for the control of brucellosis utilizing transfer factor. Initiate studies to develop the interrelation of cell-mediated immunity with humoral antibody in cattle vaccinated with Strain 19.

C. University of California, Davis - Dr. Margaret Meyer.

1. Title - Epizootiology of Brucellosis: Evolution and Taxonomy of Brucella Organisms.

2. Objective - Assess potential for mutability within the genus brucella and evaluate characteristics and probable origin of naturally occurring atypical brucella organisms. Determine host specificity and virulence of laboratory-induced revertant brucella.

D. Colorado State University - Dr. Lloyd H. Lauerman, Jr.

1. Title - Brucellacidal Capacity of Bovine Phagocytes.

2. Objective - Determine if the hydrogen peroxide--halide dependent myeloperoxide system is the major brucellacidal mechanism in

bovine polymorphonuclear leucocyte granules.

E. University of Florida - Dr. E. M. Hoffman and Dr. G. A. Berkhoff.

1. Title - Improved Methods for Diagnosis of Bovine Brucellosis.

2. Objective - To develop a standard indirect hemolytic test procedure and evaluate the test in cattle with defined vaccination and infection status.

F. Iowa State University - Dr. Edward L. Jeska.

1. Title - Interaction of Bovine Phagocytic Cells and Brucella Organisms.

2. Objectives.

a. Determine the extent of phagocytosis of brucella organisms by phagocytes from infected and noninfected cattle.

b. Determine relationship of phagocytic activity and killing of brucella by cells from normal and immune cattle.

G. Louisiana State University - Dr. Fred Enright.

1. Title - Immunological and Pathological Responses of the Bovine Fetus to Brucella abortus.

2. Objective - Determine the phagocytic, humoral, and cell-mediated responses of bovine fetuses to Brucella abortus infection.

H. University of Minnesota - Dr. Don Johnson, Dr. C. Muscoplat, and Dr. R. K. Anderson.

1. Title - Brucellosis: Cell-Mediated Immunological Mechanisms Relating to Diagnosis and Pathogenesis in Cattle.

2. Objectives.

a. Determine the limits of variability and reproducibility of the lymphocyte stimulation test as used to diagnose Brucella abortus infections in cattle and further determine effect of age, pregnancy, and state of lactation on the lymphocyte response.

b. Characterize, purify, and identify components of soluble brucellar antigens which are active in lymphocyte stimulation.

c. Develop and evaluate other cellular immunologic procedures for diagnosis and prevention of bovine brucellosis.

I. University of Missouri - Dr. Gerald Buening and Dr. W. H. Fales.

1. Title - Cell Mediated Immune Response by Chemical Modification of _Brucella abortus_ Antigen.

2. Objective - To chemically modify _B. abortus_ cells or protein fractions of the organism to preferentially induce a cell mediated response with no, or very low, antibody response capable of protecting animals against brucellosis.

J. Montana State University - Dr. N. D. Reed and Dr. J. E. Cutler.

1. Title - Animal Models for Brucellosis Research.

2. Objective - Evaluate the roles of cell mediated immunity, antibody of different classes, and phagocytic cells in resistance to _Brucella abortus_ infections.

K. University of Tennessee - Dr. Bob A. Freeman and Dr. Gordon D. Schrank.

1. Title - Immunity to Brucellosis at Mucosal Surfaces.

2. Objectives.

a. To elucidate steps in colonization and penetration of bovine mucosal surfaces by _Brucella abortus_.

b. Determine effects of local humoral and secretory immunity to infection by _B. abortus_.

c. Develop procedures to inhibit mucosal colonization and penetration of _B. abortus_.

L. Texas A & M University - Dr. L. G. Adams and Dr. F. C. Heck.

1. Title - Development of Methods for Diagnosis of Bovine Brucellosis.

2. Objectives.

a. Develop reproducible enzyme labeled antibody (ELA) and cell mediated immunity (CMI) tests and adapt these for use in routine diagnosis.

b. Using cattle with bacteriologic evidence of infection, evaluate ELA and CMI procedures in comparison with currently accepted standard and supplemental serologic tests.

c. Develop and evaluate direct and indirect ELA procedures for detection of brucella antigen in tissue homogenates of infected cattle.

d. Evaluate ELA and CMI procedures for ability to differentiate between infected and vaccinated cattle.

e. Determine the existence and role of immune complexes in the sera of infected cattle.

M. University of Vermont - Dr. Warren R. Stinebring.

1. Title - Detection of Early *Brucella abortus* Infection in Cattle.

2. Objectives.

a. Develop diagnostic procedures based on detection of circulating antigen or viable cells of *Brucella abortus* in infected cattle.

b. Evaluate these procedures in comparison with current diagnostic tests.

N. University of Wisconsin - Dr. David T. Berman, Dr. Gary A. Splitter, and Dr. William H. Stone.

1. Title - Cellular Interactions in Immune Response Mechanisms in Brucella Infected and Immunized Animals.

2. Objectives.

a. Determine the responsiveness to purified brucella antigens of presensitized bovine lymphocyte subpopulations.

b. Determine how such lymphocytes regulate host responses during brucella infections and immunization and the role of the major histocompatability complex of cattle in this interaction.

c. Examine the mechanism for failure of infected cattle to manifest seroconversion before abortion or parturition.

O. NADC, SEA-FR - Dr. B. L. Deyoe.

1. Title - Brucella Infections in Swine.

2. Current Objective - Experimental work at minimum at present time due to current emphasis on bovine brucellosis.

P. NADC, SEA-FR - Dr. B. L. Deyoe, Dr. T. A. Dorsey, Dr. L. Tabatabai, Dr. S. S. Stone, and Dr. M. Phillips.

1. Title - Brucella Infections in Cattle.

2. Current Objectives.

a. Effect of reduced dosages of B. abortus Strain 19 vaccine in yearling heifers and heifer calves. (Determine effect of reduced dosages on immunogenicity and postvaccinal responses on above age-group cattle) - cooperation with and supplying of various samples to other investigators also.

b. Development of specific antigens by isolation, characterization, and purification of B. abortus antigenic components. Efforts concentrated on differences between Strain 19 and field strains of B. abortus.

c. Development of nonviable cell fraction vaccine capable of inducing effective immunity without adverse side effects.

d. Isolation and characterization of toxic components of virulent and attenuated B. abortus and determine effect on pathogenesis of the disease.

e. Isolation and characterization of immunoglobulins in serums from brucella infected animals.

f. Cooperation with SEA-FR, Auburn Regional Parasite Laboratory and Auburn University to determine resistance of cattle with variable postvaccinal CMI responses.

2. APHIS-VS sponsored projects.

1. Auburn University - Paul Schnurrenberger and Robert Brown.

1. Title - Latent Brucella Infections in Cattle Following Prenatal or Postnatal Exposure.

2. Objective - Investigate persistence and manifestation of brucella infections in calves exposed in utero or postnatally by ingestion of milk from infected cows.

B. Los Alamos Scientific Laboratory - Dale Holm, Gary Seawright, and Mort Sanders.

1. Title - Serologic Test Development - Enzyme Labeled Antibody Test.

2. Objectives.

a. Complete the standardization of the enzyme labeled antibody test procedure so that it is ready for field evaluation.

b. Complete the mechanization of a semi-automated ELA test system so that serum dilutions and readout can be done accuately and rapidly.

C. Michigan State University - Norman B. McCullough and Terry Conger.

1. Title - Cell Mediated Immunity Study.

2. Objectives.

a. Determine if brucella sensitized lymphocytes or their extracts obtained from an immune bovine confer adequate protection against brucella exposure in recipient, susceptible cattle.

b. Determine if nonspecifically stimulated macrophages will confer short term (2 to 5 weeks) protection against exposure and infection with brucella in cattle.

c. Determine suitable in vitro tests for monitoring cell mediated immunity to brucella in individual cattle.

D. National Veterinary Services Laboratory, Ames, Iowa - D. E. Pietz and M. Gilsdorf.

1. Title - Evaluation of Strain 19 Vaccination in Adult Cattle Using Various Reduced Dose Levels.

2. Objectives.

a. Determine the optimal dose to minimize the serologic response and maximize protection against later exposure to virulent brucellae.

b. Determine the systemic response following vaccination and exposure by remote temperature sensing methods.

c. Determine the frequency of shedding of brucella in vaginal secretions and in milk following vaccination and challenge.

E. University of California - Margaret Meyer.

1. Title - H-38 Vaccination Trial. (This trial has been completed).

2. Objectives.

a. Determine the therapeutic value of H-38 vaccine, and compare the value of one versus two doses of vaccine.

b. Determine the prophylactic value of H-38 vaccine, and compare the value of one versus two doses of vaccines. The second dose was given 2 months after the first in both trials.

F. University of Wisconsin - David T. Berman and Lois Jones.

1. Title - Antigen Purification and Test Development.

2. Objective - Investigate methods for distinguishing antibodies to brucella produced by cattle exposed to virulent organisms from those produced by cattle vaccinated with live Strain 19 or inactivated Strain 45/20 vaccines using various purified brucella antigen preparations and test methods.

G. Wyoming Game and Fish Department, Cheyenne, Wyoming - Tom Thorne.

1. Title - Immunologic Response of Elk to Parental Vaccination Against Brucellosis.

2. Objective - Determine the immunologic response of elk to brucellosis vaccination and compare it to the response of cattle.

Within the past month (July, 1978), results have been reported of field trials on adult vaccination in infected herds, and on the serologic responses of sexually mature heifers to graded doses of strain 19 under controlled conditions. Both the field and controlled groups of investigations, included collaborative studies with investigators in other laboratories, to determine the specificity and sensitivity of supplemental serologic tests, and of new lymphocyte stimulation tests. Other USDA sponsored research reported, in part, includes the California studies on H-38 vaccine, studies on bovine antibody response to protein antigens of _B. abortus_, and on automation of enzyme linked antibody tests.

Evaluation of serologic tests under field conditions have also been reported during 1978 from Australia and from New Zealand, results of skin tests with protein antigens from France, and a variety of basic investigations on the organisms and host responses from various laboratories around the world.

Without making an attempt to review the papers individually, several points seem to us to be noteworthy.

1. Work with adult vaccination with reduced doses of Strain 19 has reached the point where we feel that the proposals made in Section 6 of this report are justified.

2. There is a clearer definition of the sensitivity and specificity of supplemental tests, and of their utility in infected herds in which whole herd vaccination is being carried out. The Rivanol and Complement Fixation tests appear to be most useful in this type of epidemiologic situation.

3. Very promising results have been obtained with new lymphocyte stimulation tests which may add to laboratory capabilities in diagnosis. Additional data on more animals are needed.

4. Results of the most recent studies with H-38 vaccine confirm the conclusion of the National Academy Committee, that this vaccine has no useful role in the U.S. at this time.

5. Sponsored investigations on most of the topics suggested by the Research Community are in progress. There is a significant amount of collaboration among research groups, so that the same animals are furnishing material for more than a single project. Various investigators are furnishing materials such as antigens, sera, and other materials to each other. This degree of collaboration is a very positive accomplishment which will accelerate progress.

6. In our investigations for this report we note two major deficiencies in availability of data and of active research. Epidemiological data on the program as presently collected in the states and compiled by APHIS staff do not provide an epidemiological or administrative data base which is adequate for precise evaluation of program and performance. There is a wealth of information available, and its collection and processing in a form which will permit its evaluation is an important component of the program which deserves support both as a legitimate research effort and for program operations.

While the biological aspects of brucellosis research are fairly thoroughly covered in the sponsored projects, we find that there is inadequate attention being paid to the interaction of epidemiology and the dynamics of the livestock industry. Our own efforts at modeling the disease and program policy have convinced us that this is a legitimate area for further investigations. This includes research on the cyclic, geographic, movement, marketing and other economic trends specifically as they influence disease control.

In the area of research administration, SEA and APHIS have made the following response to the National Academy Committee recommendations, which this Brucellosis Technical Commission supported formally in letters to Drs. Mulhern and Edminster. The following is extracted from their official response:

"Research Administration:

ARS and APHIS have expended funds to support brucellosis research and field trials for many years, but this support had been decreased during the past decade. This has been due to budget and personnel restrictions, and to higher priority eradication and control needs, e.g., Venezuelan equine encephalomyelitis, viscerotropic velogenic Newcastle disease, and hog cholera. At this point, we must emphasize that Congress has recognized the concern of industry and other interested groups and has increased funding for brucellosis research and eradication. This funding increase will permit and encourage expansion of both basic and applied research. APHIS and ARS are looking to the scientific community--State, Federal, and private--for major "breakthroughs." This additional information will serve to develop the broad technical base of knowledge that may enhance industry acceptance and reduce the economic impact and time necessary to accomplish brucellosis eradication.

Our Agencies are also aware that the very best use of research evaluation of research and an exchange of ideas between the two Agencies and among interested groups is recognized. In this regard, APHIS and ARS are establishing an advisory panel to evaluate present and proposed brucellosis research and field studies. The Brucellosis Subcommittee strongly urged that such an advisory panel be appointed. The significance of this advisory panel should be recognized because it does reflect the desire to respond to current needs and future problems of the brucellosis eradication program. It is our opinion that research must continue to address the pressing needs of industry and State/Federal programs. These needs keep research relevant, and numerous examples can be cited to suggest that, in fact, such responsiveness enhances the ability to anticipate research opportunities. In addition, we are cognizant of the valuable recommendations made by brucellosis research scientists at the annual meeting of The Brucellosis Research Conference and by The Brucellosis Committees of the U.S. Animal Health Association, The Livestock Conservation Institute, and others.

We visualize the advisory panel as that group to whom all brucellosis research and field study proposals (intramural and extramural) will be submitted. The panel will also evaluate the progress and direction of ongoing research and field studies. All proposals will be categorized and given a priority within these categories. If there are obvious omissions in categories of research

investigations, the panel can advise various research teams of needed research. This mechanism should insure an effective balance between applied and basic research. We anticipate the panel will convene at least semian nually to review proposals and submit their evaluations to APHIS or ARS. They could also recommend potential projects to other funding agencies, such as the Coopera tive State Research Service, the National Institute of Health, or the Fish and Wildlife Service.

The joint APHIS-ARS Advisory Panel will be comprised of members from industry, universities, and State regulatory agencies serving on a rotating basis. Mem bers selected from APHIS and ARS line and staff positions will serve on either a permanent or rotating basis."

The Commission feels that it is important to emphasize that although there are already promising developments from the increased funding for research and field investigations, adequate development of these leads requires assurance of funding at sufficient levels for a reasonable period of years. Premature reduction of research support in the 1960's resulted in a deficient technological base for advancement of the program in the 1970's. We hope that the mistake will not be repeated.

The Commission believes that the reestablishment by U.S.A.H.A. of its Science Advisory Committee in 1977 was a useful step. As research data and new technology are produced by the enhanced research program over the next few years, it will be imperative for it to receive critical review for possible application in the national program. This process was highly effective during the period when greatest strides were being made toward local eradication from 1952 to 1966. We believe that a comparable contribution can be made in integration of research findings into control leading to local eradication during the next decade. We also believe that the establishment of centers of research expertise in the high prevalence areas is a very favorable development. We urge that the State and Federal regulatory agencies make maximum contact with these centers both for technological advice and for assistance in training their personnel. They in turn can be of assistance to the researchers in bringing field aspects of the disease to their attention and in testing new research findings under field conditions, with a view to applying newest technology to the program.